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09-AFC-7
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February 12, 2010

Alan Solomon
Project Manager
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

RE: **Palen Solar Power Project, Docket No. 09-AFC-7**
Supplemental Responses to CEC Data Requests
Technical Areas:
Biological Resources – DR-BIO-60 through DR-BIO-62
& Preliminary Geomorphic Aeolian and Ancient Lake Shoreline Report

Dear Mr. Solomon:

Our January 6, 2010 responses to CEC data requests addressed the sand dune topic at the proposed Palen Solar Power Project while indicating that additional data was to be provided. Attached please find our supplemental responses to data requests DR-BIO-60 through DR-BIO-62 and the additional data provided in the Preliminary Geomorphic Aeolian and Ancient Lake Shoreline Report.

If you have any questions on these data responses or on the report itself, please feel free to contact me directly.

Sincerely,

Alice Harron
Senior Director, Development

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Supplemental Responses to CEC Workshop Data Requests DR-BIO-60 to DR-BIO-62

Biological Resources

Palen Solar Power Project

Docket No. 09-AFC-7

February 12, 2010

Alice Harron
Senior Director of Project Development
1625 Shattuck Avenue, Suite 270
Berkeley, CA 94709-1161

DR-BIO-60

Information Required:

Sand Dune Ecosystem Maintenance. Please provide information, including any appropriate modeling and quantitative analysis, describing how wind and water contributes to the creation and maintenance of the sand dunes, partially stabilized sand dunes, and any other habitats potentially occupied by Mojave fringe-toed lizard in the vicinity of the project area.

Response:

See attached Preliminary Geomorphic Aeolian and Ancient Lake Shoreline Report prepared by Miles D. Kenney PhD, PG.

DR-BIO-61

Information Required:

Impacts of Project to Sand Dune Ecosystem. Please provide an analysis, including any appropriate modeling or quantitative assessment, of the potential direct and indirect effects of project construction and operation (for example, alteration of hydrology, dust palliatives, wind fencing) on creation and maintenance of sand dunes, partially stabilized sand dunes and nay other habitats potentially occupied by Mojave fringe-toed lizard.

Response:

The Report concludes:

- Natural aeolian sand migration in Zones II and III will be obstructed by development of the PSPP and potentially *may slowly adversely impact MFTL habitat immediately to the southeast of the property.* The impact on sand deposits toward the southeast of the decrease in sand migration through the proposed footprint will *likely be evident only after decades.*
- A decrease of drainage flow within the Project site after construction will not adversely affect identified MFTL habitat outside of Project site after construction.
- a low profile access road as proposed in the Project design would not adversely affect aeolian sand transport toward the south and east, as wind blown sand was directly observed to easily transect such structures and to travel at heights of at least six feet
- Comparison of the proposed construction design and identified MFTL locations within the Project site (EDAW, 2009; see Plate 2 and 3), shows that MFTL habitat will be adversely impacted by the proposed development. Current evidence indicates that the aeolian sand source for the MFTL habitat sand deposits within Zones II and III within the Project site property will likely remain for decades into the future.

The impacts noted have already been accounted for and mitigation has already been proposed (See Response to Data Request 62 below).

DR-BIO-62

Information Required:

> Mitigation Plan for Impacts to Sand Dune Ecosystem. Please provide a detailed mitigation plan for avoidance and minimization of direct impacts to Mojave fringe-toed lizard habitat. The mitigation plan should include measures for minimizing direct impacts to preserved habitat during construction, indirect effects of operation, and a plan for compensatory mitigation.

Response:

The PSPP impacts have identified impacts to both DT and MFTL habitat. The range of the MFTL on the PSPP overlaps with the range of the DT. The direct impact to DT habitat as identified (3,874 acres) is approximately two times the amount of direct impact to MFTL habitat (1,735 acres). The compensatory mitigation required to offset impacts to DT habitat is expected to be adequate to offset direct impacts to MFTL habitat as well as potential indirect impacts to offsite MFTL habitat.

In addition, the offsite indirect impacts to state waters downgradient of the Project site, including those within MFTL habitat, are being mitigated for by the Project as permanent impacts.

Preliminary Geomorphic Aeolian and Ancient Lake Shoreline Report

Miles Kenney PhD, PG

Consulting Geologist

JN 708-09

Preliminary Geomorphic Aeolian and Ancient Lake Shoreline Report

Palen Solar I Project
Riverside County, CA

Prepared By

Miles D. Kenney, Ph.D, PG
Encinitas, CA 92024

Prepared for:

Palen Solar I, LLC

February, 11, 2010

To: Dr. Ted St. John
Senior Ecologist
AECOM, Inc.
1461 E. Cooley Drive, Suite 100
Colton, CA 92324

From Miles D. Kenney PhD, PG
Consulting Geologist
215 Calle de Madera
Encinitas, CA 92024

Date: February 11, 2010

Re: Preliminary Geomorphology Report of the Aeolian Sand System and Ancient Playa Lakes in the Palen Dry Lake Region, Proposed Palen Solar Energy Project, Chuckwalla Valley, Riverside County, CA

Here are the preliminary findings and conclusions regarding aeolian sand sources, migration and deposition within the Chuckwalla Valley with emphasis on the region of the proposed Palen Solar Power Project (PSPP or Project). Palen Solar I, LLC is proposing to develop a 500-megawatt (MW) solar thermal power generating facility on public lands managed by the Bureau of Land Management (BLM) on a site in eastern Riverside County, California.

This report has been prepared to respond to California Energy Commission (CEC) Staff Data Requests (DR) (DR-BIO-60, 61 and 62) to provide information regarding the aeolian sand system in the Chuckwalla Valley. The specific focus is to investigate aeolian sand sources and pathways contributing to loose sand deposits within the vicinity of the areas of the Project site that are considered habitat for Mojave Fringe-Toed Lizard (MFTL) and also to address potential Project impacts to the aeolian sand system and maintenance of the existing MFTL habitat . In addition, preliminary data are discussed regarding the temporal and spatial distribution of ancient playa lakes within the Palen Dry Lake basin. The findings and conclusions in this report supersede earlier preliminary material developed by the author for the Project. .

Miles Kenney, Ph.D., P.G.
Supervising Geologist

REGISTERED GEOLOGIST
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2/28/10
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INTRODUCTION

The bulk of this report provides preliminary findings regarding the aeolian sand migration, deposits and sources in the region of the Palen Solar Power Project (PSPP) site. This report focuses on sand transport and dune formation rather than direct impacts of Project construction on the Mojave fringe-toed lizard (MFTL). The conclusions section of the report provides preliminary findings regarding the temporal and spatial behavior of ancient playa lakes within the Palen Dry Lake basin.

Two primary questions must be addressed to assess potential direct impacts and long term maintenance of MFTL habitat potentially associated with the proposed development:

1. What is the direct impact of the proposed Project footprint to existing MFTL habitat (although this is a function of direct disturbance of MFTL habitat by Project activities and is not directly related to aeolian sand migration)?

2. Would the proposed Project produce a sufficient decrease in aeolian sand source to impact existing MFTL? This question, in turn, involves four factors.

    - What is the source of sand to the MFTL habitat?

    - How much aeolian sand is currently generated by the current ground within the proposed footprint of the Project (intrawashes)?

    - What is the relative significance of a potential decrease in aeolian sand generation by surface water flow re-routed around the proposed solar facilities?

    - Would the proposed development obstruct existing sand migration corridors and, if so, to what degree?

SITE PHYSIOGRAPHY

The Project Site lies on a broad, relatively flat, northward sloping surface dominantly underlain by Holocene alluvial drainage and latest Pleistocene older alluvial fan deposits derived from the Chuckwalla Mountains to the south. These alluvial deposits have formed a large bajada and piedmont surfaces between the Chuckwalla Mountains to the south and the Palen Dry Lake-Chuckwalla Valley toward the north. Within the Project site the alluvial deposits are overlain and interbedded with Quaternary aeolian sand and playa lake deposits toward the north. The Project site generally slopes from south to north with elevations of approximately 693' above mean sea level (msl) in the southwest corner of the property to 423' feet above msl in the northeast corner of the property. The site is occupied by a community of low creosote and bursage scrub vegetation.

METHODOLOGY AND SCOPE OF WORK

The preliminary results provided in this report are primarily based on review of existing literature, site field mapping, soil profile analysis, site photographs, experience in the region, and data obtained from Google Earth. These are discussed individually below.

Literature Review

Reviewed literature (see reference section of this report) provided a great deal of information from studies regarding regional sand migration corridors, types of sources for dune systems in the Mojave

Desert, and age of aggradational events of dune fields in the southwestern U.S. No local dune studies have been identified for the Chuckwalla Valley sand dune system, however, some studies do refer to the Dale Lake to Mule Mountains sand corridor system.

Field Mapping

Field mapping was conducted throughout the Chuckwalla Valley with an emphasis on the Project site (see Plate 1). Field work provided the majority of the data utilized in this report concerning the type and age of aeolian deposits, areas of active sand transport, and characterizing areas containing active, dormant and relict dune fields.

Numerically Dated Desert Soils from the Coachella Valley

Previous large scale fault investigations covering more than 6,000 acres within the eastern Coachella Valley (Petra, 2007a, 2007b) were overseen by the author of this report. These studies were located 80 miles due west of the Project site within Coachella Fan alluvial deposits shed from the Little San Bernardino Mountains. As part of the latter studies, numerous soil profiles were evaluated on a morphostratigraphic series of late Pleistocene to Holocene age preserved fan surfaces. The soils within fan deposits represent a chronosequence or a group of soil variables such as topography, parent material, vegetation, and climate that are roughly equal (Jenny, 1941). These soil descriptions and ages were utilized to provide minimum preliminary soil profile ages within this study, as discussed further in following sections.

Google Earth

Google Earth is a free internet program provided by Google. The program allows for evaluation of photographic images of the surface of the earth with scale and location. Locations are provided with latitude, longitude and elevation.

Site Photographs

Photographs were taken during field mapping at nearly every site visited. The locations of the selected photographs are shown on Plate 3. Selected photographs with interpretation are provided on Plates 4 through 9.

REGIONAL GEOLOGY AND GEOMORPHOLOGY

General Geomorphology of the Basin and Range Geomorphic Province

The proposed PSPP is located in the northwest Sonoran Desert Geomorphic Province and is just south of the Mojave Desert Geomorphic Province. These regions exhibit strikingly similar geologic history and resulting geomorphology. These two geomorphic provinces exist within the larger Basin and Range Geomorphic Province (BRGP). For the purposes of this site evaluation, the use of the term BRGP will include the Mojave and Sonoran Desert Geomorphic Provinces.

The geomorphology of the BRGP is dominated by mountains and valleys produced during dramatic tectonic extension in the western and southwestern United States primarily during the mid to late Tertiary (Nelson, 1981; Armstrong, 1982; Rehrig, 1982; Hamilton, 1982; Anderson, 1988; Wernicke, 1992). The lithospheric tectonic extension caused normal faulting in the brittle upper crust allowing for crustal thinning and produced fault bounded mountain ranges (horsts) and valleys (grabens) across the BRGP. The crustal extension led to the development of widespread Tertiary fanglomerates and abundant pressure release volcanism. Many of these deposits associated with the widespread extension were subsequently tilted, folded and faulted post formation during the ongoing extensional tectonism.

The mountains bounding the Chuckwalla Valley near the PSPP site are primarily composed of igneous, metamorphic and volcanic rocks. These mountains ranges include the Palen to the north-northwest, the McCoy to the north-northeast, the Mule to the southeast, and the Little Chuckwalla to the south. Numerous basement constrained faults are exposed in the mountain basement rock terranes dominantly associated with Mesozoic compression and Tertiary extensional tectonics. These faults do not displace Quaternary deposits and no active faults are known to exist within the Chuckwalla Valley area (Jennings, 1994). Thus, there is little evidence to suggest Holocene age or even late Pleistocene age tectonic vertical movements have occurred in the region. Typical geomorphic terranes within the BRGP include mountains flanked by an apron of alluvial fans (proximal, middle and distal facies), and playa lakes (valley sinks). Each of these terranes is discussed in more detail below in addition to a general discussion on weathering processes.

General Weathering Processes

Erosion is primarily produced by chemical and mechanical weathering processes. Primary structures and composition such as pressure release jointing, fracturing, faults, foliation, and types of silicate minerals all play a role in the ability of the bedrock in the mountains to erode. Water is an important factor in both the weathering and transport of rocks and sediments. Water assists chemical reactions and is a strong control on the amount and type of vegetation. Flowing water is also the dominant mode of transport of the erosional products which move the sediment (bed load and suspended load) down the drainages to be deposited. Wind also has the ability to mobilize sediment and does play a larger role in desert environments; however it is a distant second to water in terms of total mass mobilized.

Mountain Geomorphic Terranes

Mountains within the BRGP generally have relatively steep slopes, erosional “V”-shaped valleys due to drainage erosional processes, and local escarpments along the mountain edges. Within the BRGP, erosional processes dominate within the mountainous terranes. Relatively minor deposition does take place in mountain terranes within the drainages as stream terraces. Primary structures and composition of the rocks such as pressure release jointing, fracturing, faults, foliation and chemical composition all play a role in the ability of the mountain rocks to erode. Water is the dominant form of transport of the erosional products which move the sediment (bed load and suspended load) down the drainages to be deposited.

Alluvial Fan Geomorphic Terranes

The flanks of most mountains ranges in the BRGP piedmont geomorphic terranes contain alluvial fan deposits derived from sediments from erosion of the local mountains (Dohrenwend et. al., 1991). The fans are derived from flowing water emanating from the mountain valleys. The exit point of the drainage from the mountain front is called the apex. At the apex, the fan drainage is no longer confined to the mountain valley and the channel has the ability to fan out in numerous directions leading to a cumulative “fan” shaped deposit. The fans are dominantly composed of fanglomerates and debris flows in the proximal and mid fan sections, and generally grade to fluvial sands in the distal axial valley fan section. Sediment sizes generally get finer further from the fan apex. Fan deposition rates have varied during the Quaternary. Although the correlation that wetter climates during the Pleistocene glaciations played a role in relatively large aggradational fan events throughout the BRGP is debated, it is likely that the climatic maximums during the ice ages led to periods of increased fan deposition (Bull, 1979; Bull, 1990; Dohrenwend, et. al., 1991; Harvey and Wells, 2003; McFadden et. al. 2003). Drainages within the BRGP exhibited discharge an order of magnitude larger than today during pluvial (glaciations) periods (Morrison, 1991; Dohrenwend, et. al., 1991). One effect of wetter climates of the Pleistocene was likely larger storm strength intensity and frequency that generally caused a shift down slope of the proximal, middle and distal fan facies. Thus, it is common to identify distal fan facies deposited during the Holocene overlying late to latest Pleistocene coarser grained middle fan facies.

Valley Sinks – Desert Playa and Pluvial Lakes

One of the key geomorphic characteristics of the BRGP is that drainages terminate in local or regional valley sinks (i.e. Playa lakes) and not the Pacific Ocean or Sea of Cortez (USGS, 1967). The region truly is a “basin”. The Colorado River located east of the site near Blythe terminates in the Sea of Cortez and is thus an exception to the vast majority of drainages in the BRGP. Once the extensional tectonics subsided during the late Tertiary, the uplifted mountains continued to erode without further uplift and the local valleys continued to in-fill with sediment. Thus, since the regional tectonic extension ceased, erosional and depositional processes have dominated the area. Over time the aerial extent of mountain ranges and valleys have decreased and increased respectively as mountains erode and adjacent valleys filled with sediment.

Many of the BRGP valley sinks contained lakes most of which existed during the glacial maximums of the Pleistocene (Morrison, 1991; Reheis, 1999; Reheis, 2005; Castiglia and Fawcett, 2006; Reheis et. al., 2007). A distinction can be made between Pluvial and Playa lakes. Pluvial lakes formed during Pleistocene glacial maximums that existed for thousands of years. Pluvial lakes are also referred to as Perennial Lakes. Playa lakes are ephemeral and thus only last for a short period of time before they dry up. G.I. Smith (Dohrenwend, 1991) provided excellent geologic differences between pluvial and playa lake deposits. Pluvial (perennial) lakes are inferred where: (1) sediment hues are green, yellow, or olive-brown (5GY, 10Y, or 5Y); (2) clasts are well sorted and their sizes range from clay to medium sand; (3) bedding is distinct, thin, or laminar; (4) aquatic fossils are noted; and/or (5) saline layers are absent. Play lake deposits are inferred where: (1) sediment hues are orange or brown (10YR, 5YR0; (2) clasts are poorly sorted and their sizes range from silt to sand; (3) bedding is indistinct, massive, or deltaic; (4) aquatic fossils are absent; and/or (5) saline layers are present. Smith (Dohrenwend, 1991) indicated based on this criteria and deep boring data within Palen and Ford Dry lakes, that both of these basins only contained Playa lake deposits to depths of ~160 meters (bottom of borings).

During the early and late Holocene some valley sinks developed relatively minor pluvial lake stands within the BRGP (Morrison, 1991; Dohrenwend, 1991).

Eolian Deposits and Source Areas

Within the BRGP, dune deposition (aggregation-growth) generally occurred during relatively dry periods that dried up pluvial lake basins, following wetter climates that generated considerable sediment supply within regional drainages (Dohrenwend, et. al., 1991; Lancaster and Tchakerian., 2003). The last major regional sand dune aggradational event occurred near the Holocene-Pleistocene boundary (Dohrenwend, et.al. 1991). However, a global dry period during the mid Holocene (7-5kya [5 to 7 thousand years ago]) that followed the relatively wetter climate cycle (Forman, et. al., 2001; Jenny et. al., 2002; Fahu et. al., 2003; Umbanhowar et. al., 2006; An et. al., 2006; Jenny et. al., 2002) also allowed for sand dune growth of within the Mojave Desert region 7 to 4 ka (Dohrenwend, et. al., 1991; Lancaster, 1997). In addition, some dune fields in the Mojave Desert observed dune rejuvenation approximately 400 years ago (Dohrenwend et. al., 1991, pg. 246; Lancaster, 1997). In terms of total mass, most major sand dune deposits existing today are considered fossil formations as they likely have not actively grown or migrated to a large degree during the late Holocene (Dohrenwend, et. al., 1991).

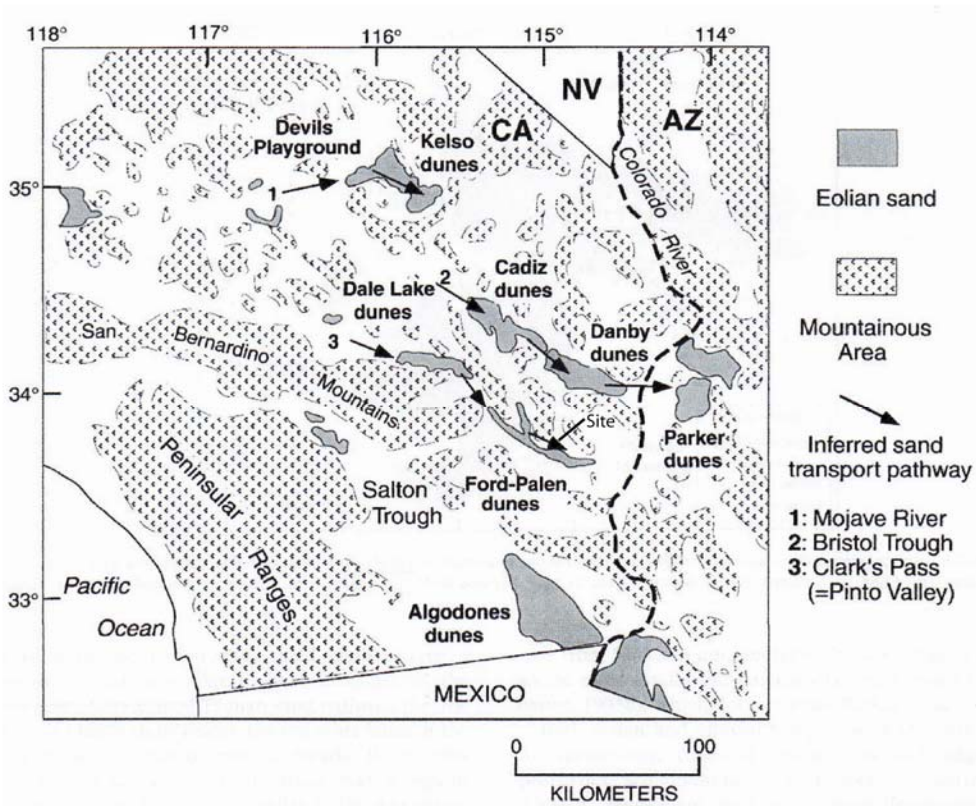
Most of the sand dunes in the local BRGP are produced by sand moving east to southeast associated with Pacific Ocean derived weather fronts (see Figure 1). However, this migration is also altered by topographic controls on wind when channeled along mountain fronts and within valleys (Laity, 1987). Although wind data for areas of the region indicate that strong summer monsoonal winds from the south occur, they apparently do not play a large role in terms of large sand transport in the region of the Project. Geomorphic evidence for this is provided by the form of the dunes. For example, well developed transverse dunes (i.e., barchan) within Palen Dry Lake clearly indicate that the dominant winds transporting directions responsible for the majority of aeolian sand transport is toward the east to southeast within the Chuckwalla Valley.

One method to analyze annual wind data to determine potential sand entrainment and migration direction is the evaluation of the Resultant Drift Potential (RDD). This method requires temporal velocity wind data from throughout the year that obtains data regarding how fast the wind moved and for how long. To determine the RDD, the Drift Potential vector for each wind that occurred during the year exceeding the threshold wind velocity (~12 knots or ~14 mph) is evaluated, which is proportional to the length of time the wind blew greater than the threshold wind velocity (Tsoar, 2004). Thus, an individual DP value and vector is determined for each wind direction that blew greater than the wind threshold velocity. The DP values are proportional to how much stronger it was relative to the threshold wind velocity and how long it blew at those speeds. Adding up all the DP values provides a parameter of the potential maximum amount of sand that could be eroded by the wind during a year for all wind directions (Tsoar, 2004). Adding all the vector units of the DP values provides a resulting vector called the Resultant Drift Potential (RDP). The RDP vector provides a measure of the primary direction of sand transport (if there is one). The findings section of this report provides a RDP determined for the Blythe Airport located at the eastern end of the Chuckwalla Valley.

Three primary aeolian sand corridor systems have been identified in the regional BRGP (Zimbelman et. al., 1995; Clarke and Rendell, 1998). These include: Along the Mojave River from the Devils Playground to the Kelso Dunes; The Bristol Trough system which extends southeast from the Bristol Playa to the Colorado River and the Clarks Pass system that extends from Dale Dry Lake to just east of Ford Dry Lake (Figure 1 below; also see Muhs et al., 2003; Lancaster and Tchakerian, 2003).

The source for sand dune sediment within most BRGP dune fields likely is a combination of regional sand corridors, playa lakes and local active washes along the sand corridors. Recent work suggests that sediment for most dune fields in the BRGP west of the Colorado River is originally derived from active washes (both locally and regionally along the sand corridors), migration along sand corridors, and transport from dry playa lakes (Lancaster and Tchakerian, 2003; Muhs et. al., 2003; Ramsey et. al., 1999). However, it is clear from review of available literature that site specific studies typically need to be conducted within dune fields to identify the relative contribution from these sources. For example, a study by Muhs et. al. (2003) found that dune fields on opposite sides of the Colorado River are mineralogically distinct and have different sources. They identified that the Parker Dune field located just east of the Colorado River and northeast of the site is supplied by sediment derived from the Colorado River valley itself and not transport of sand from the Danby dune field located west of the Colorado River valley. The Muhs et al. (2003) study indicated that large washes can be both a large source of sediment for dune fields, and also a large impediment to sand wind entrainment.

Figure 1 - Primary aeolian sand migration corridors in the BRGP (Mojave and Sonoran Deserts)



Drainage Systems

The BRGP primarily exhibits braided drainage systems containing abundant coarse grained sediment bed load associated with an arid region. Drainages typically begin in the mountainous regions, then extend over alluvial fans and terminate in valley sinks (often playa lakes). Drainages within the mountains typically exhibit V-shaped eroded valleys due to slope erosion and drainage down cutting. Mountainous areas are thus primarily regions dominated by erosional processes and tributary drainage networks. As the drainages exit the mountain front they enter the region dominated by alluvial fans at the fan apex geomorphically referred to as piedmonts. Piedmonts consist of coalescing alluvial fans exhibiting a mosaic of active channels, abandoned channel segments, and interchannel surfaces or ridges (Dohrenwend, et. al., 1991). Active piedmont drainages form distributary drainage networks in areas of recent active fan deposition (current active washes) with bar and swale topography. Abandoned portions of piedmonts typically exhibit tributary drainage networks on areas of older fan deposition across relict abandoned fan surfaces. The vast majority of coarse grained sand and gravel transported by the local drainages is deposited within the alluvial fans. Near the termination of the alluvial fan system drainages become progressively less constrained within distinct channels which allows for sheet flow type deposition to occur. Eventually the drainages reach a valley terminal sink which generally represents a playa lake of nearly horizontal fine grained strata (silts and clays).

FINDINGS

SITE GEOLOGY AND GEOMORPHOLOGY

The Project site exists within the medial to distal fan portion of a series of fans and bajadas flanking the northern side of the Chuckwalla Mountains to the south. The piedmont bajadas merge with Chuckwalla Valley axis deposits consisting of aeolian sands and playa lake sediments. Topographically, Site relief is approximately 270 feet and exhibits an approximate 0.85 degree northeastward slope. The site exhibits relatively thin Holocene alluvium overlying latest Pleistocene older alluvial fan deposits in the majority of the site. Toward the northeast, relict dune and moderately active aeolian sand and playa lake deposits occur within the property. The level of aeolian sand deposits activity increases toward the northeast within the Project site and near surface playa lake deposits occur at elevations near and below elevation 426' msl.

Preserved late to latest Pleistocene age fan surfaces (Qoaf) with well developed desert surfaces (desert pavement, soil profiles) are preserved south of the site (Plate 2). Latest Pleistocene older alluvial deposits were also identified at the surface in the northeastern portion of the property along the southern limits of playa lake deposits associated with the Palen basin (Plate 2). These preserved fan surfaces represent the termination of sediment aggradational events during wetter climates of the Pleistocene ice ages (Weldon, 1986; McFadden and Weldon, 1987; Bull, 1990; Harvey and Wells, 2003; McDonald et. al., 2003).

Chuckwalla Valley Sinks – Playa Lakes

The site is located within the Chuckwalla Valley, which contains two primary valley sinks. The first is Palen Lake located immediately north of the Project , and the second is Ford Dry Lake located about 12 miles southeast of the Project site (Plate 1; Jenkins, 1967). Thus, the drainages emanating from the local mountain ranges and across local fans terminate within these local sinks. The vast majority of drainages in the BRGP and all of the drainages in the Project area are ephemeral (the drainage is usually dry and fills with water only during brief episodes of intense rainfall). The western portion of Chuckwalla Valley containing Palen Dry Lake trends northwest-southeast and then turns to approximately due east-west in the region of Ford Dry Lake. A tributary valley extends northward from the Project site between the Palen and McCoy Mountains (herein the Palen McCoy Valley).

The drainage sinks of Palen and Ford Dry Lakes contain surficial sand dune deposits underlain by ephemeral playa lake deposits (Dohrenwend et. al., 1991). Thick accumulation of lacustrine (lake) deposits generally occurred during the wetter climates of the Pleistocene glacial maximums. The age of the most recent major pluvial lakes throughout the BRGP valley sinks is latest Pleistocene (13 to 11 ka; Rehis, 1999; Briggs, 2003; Jayko et. al, 2005; Knott, 2005; Miller, 2005; Beacon et. al., 2005; Reheis, et. al., 2007). Relatively smaller Holocene lakes also occurred within many BRGP valley sinks during the early and early late Holocene (Morrison, 1991; Dohrenwend et. al., 1991).
The elevation of the current playa lake surface and sill to the east at the south end of the Palen Mountains is approximately 423 feet above mean sea level. Thus, ephemeral lake stands within Palen Lake would drain toward east and into the Ford Dry Lake basin with a high water elevation of approximately 423' msl (elevations based on Google Earth). Geomorphic and soil profile data obtained in the field provide evidence of Holocene age lake stands to elevations of approximately 424 to 425' msl and the existence of a pre-latest Pleistocene high lake stand to elevation of approximately 426' msl (Plate Exposed playa lake deposits (lacustrine deposits - Ql) exist in the valley northwest of the current dry lake area at an upper elevation of approximately 377 feet msl (see Appendix B).

A geologic map published by the California Department of Water Resources (DWR, 1963) indicates Pliocene to early Quaternary lacustrine deposits at upper elevations of 520 feet above mean sea level flanking the southern end of the Palen Mountains (see light colored deposits shown on Plate 3). These deposits are horizontal and overlain by late to latest Pleistocene alluvial fan deposits (Qoaf). A pluvial lake with surface elevation of ~520 feet msl suggests that the sill to the east likely north of the Mule Mountains within the Chuckwalla Valley has eroded more than 60 feet (520 – 460 feet) since the time of these high standing lacustrine deposits. This is assuming no local tectonic movements, which is reasonable based on previous discussions regarding local fault activity. These DWR-mapped lacustrine deposits are overlain with late Pleistocene alluvial fan deposits exhibiting very dark desert varnish.

Aeolian Aggradational Events Since the Latest Pleistocene

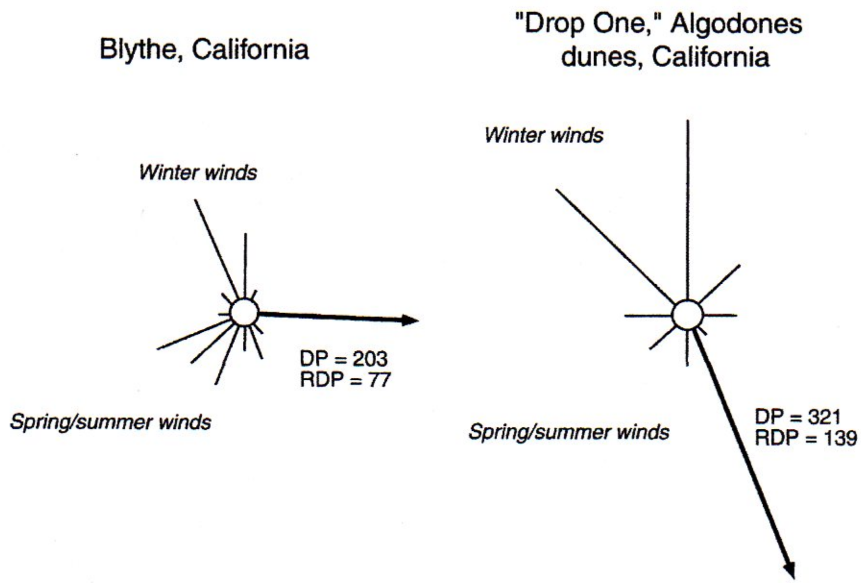
To understand the aeolian system within the Chuckwalla Valley region requires an understanding of the behavior of dune systems in the regional BRGP since the latest Pleistocene (past 13,000 years). Within the BRGP, sand dune deposition (aggregation-growth) generally occurred during relatively dry periods following wetter climates that generated considerable sediment supply within regional drainages and dried up pluvial lake basins (Dohrenwend, et. al., 1991; Lancaster and Tchakerian., 2003). The last major regional sand dune aggradational event occurred near the Holocene-Pleistocene boundary (Dohrenwend, et.al. 1991). However, a global dry period during the mid Holocene that followed the relatively wetter climate cycle (Forman, et. al., 2001; Jenny et. al., 2002; Fahu et. al., 2003; Umbanhowar et. al., 2006; An et. al., 2006; Jenny et. al., 2002) also allowed for sand dune growth within the regional BRGP 7 to 4 kya (Dohrenwend, et. al., 1991). Most major sand dune deposits existing today are considered fossil formations as they have likely have not been actively forming during the late Holocene (Dohrenwend, et. al., 1991).

Most of the sand dunes in the regional BRGP are produced by sand moving east to southeast due to resultant annual wind directions dominantly controlled by Pacific winter storms (Figures 1 and 2). However, this migration is also altered by topographic controls on wind when channeled along mountain fronts and within valleys (Laity, 1987). Zombelman et. al. (1995) identified the primary sand corridor system in the area of the site that extends from Dale Dry Lake to just east of Ford Dry Lake (Figure 1; also see Lancaster and Tchakerian, 2003). The source for sand dune sediment within most dune fields in the regional BRGP comes from a combination of regional sand corridors, local active washes along the sand corridors and playa dry lakes (Lancaster and Tchakerian, 2003; Muhs et. al., 2003; Ramsey et. al., 1999).

SEDIMENT DATING TECHNIQUES

The age of the site geologic units was estimated in both numerical and relative terms. Relative ages were assigned by stratigraphic position of the sedimentary layers. In alluvial fan environments, morphostratigraphic relationships may also provide relative ages for fan deposits. In upper fan reaches, the older preserved fan surfaces (terraces) are generally at higher elevations than younger surfaces. In distal areas of the fan, older deposits are typically buried by the younger layers. Numerical ages for sedimentary units may be assigned by careful examination of the soil profiles. For

Figure 2 – Resultant Drift Potential (RDP) Data from Blythe and the Algodones Regions.
(The Algodones dune field is located at the south end of the Salton Trough. These data indicate that the Pacific Cell winter weather fronts in combination with topographic (mountains and valleys) dominate the orientation of the RDP.)



this study, numerical ages for sediments were arrived at by correlating site soil profiles with known dated soils in the Coachella Valley (Petra, 2007a and 2007b), and should be considered approximate.

Soil Profile and Geomorphic Surface Development Ages

Soil profiles provide **minimum** dates for sedimentary units. This process estimates the minimum age of the sedimentary units based on the degree of soil profile (pedon) development at the uppermost portion of the unit and for buried soil profiles within the unit. Of primary importance is that soil profiles do not provide the age of sediments. Instead, they reflect when deposition ceased and prolonged exposure of the sediments to near-surface weathering processes initiated. A rough deposition age can be arrived at by the sum of cumulative ages of the uppermost soil pedon and all buried pedons within the unit(s). Desert soils are typically dated utilizing the Soil Development Index (SDI) method of Harding (1982). With an SDI value, a soil in question may be compared to other regional soils evaluated with the same method and dated with absolute techniques such as Carbon-14. Empirically, SDI values have shown strong correlations to soil age (Harding, 1982; Rockwell et al., 1985; Reheis et al., 1990;; Rockwell, et al., 1994; and Helms et al., 2003).

Morphostratigraphic Age Correlation

Morphostratigraphic units are the correlation of fill terrace fan deposits (soil age), into the drainages where the same units are buried by younger fan deposits. In theory, stratigraphically deeper fan deposits preserved beneath younger sediments in lower elevations may be traced to geomorphically higher positions at the proximal part of the fan system. This correlation is critical because it permits the transfer of numerical soil profile ages determined for the preserved fan surfaces (soil ages) to buried depositional units at lower elevations.

GEOLOGIC STRATIGRAPHY

Field mapping with an emphasis on aeolian deposits yielded a local stratigraphy of seven units. Stratigraphic relationships between geologic layers and analysis of preserved soil profiles in turn generated relative and numerical minimum ages for each unit. The order of unit descriptions provided below first provides those units deposited by flowing water (alluvial or lake), which are followed by descriptions of units deposited by wind (aeolian). Colors determined utilizing the Munsell Soil Color Charts (Hue Value/Color).

Alluvial and Playa Lake Unit Descriptions

Qw: Active wash deposits composed of very fine to very coarse sand with small gravel, light brown (7.5YR 6/3 dry) to yellowish brown (10YR 5/4 dry), and loose. This unit is confined within the active washes and is typically 1 to 6 inches thick in most washes, but may locally be greater than 2 feet thick in some of the larger washes. This unit was not mapped within this study. This unit is the youngest mapped at the BSPP site.

Qal: Quaternary Alluvium exists across most of the Project site and is composed of unconsolidated very fine to coarse sand with small gravels, brown (7.5YR 5/3 dry), moderate to well bedded, and loose. Unit Qal as mapped represents Holocene braided channel deposits associated with medial to distal fan facies. The unit represents a tabular shaped deposit that overlies Quaternary Older Fan deposits (Qoaf) throughout much of the site (also see SWCA, 2009 and Kleinfelder West, Inc, 2009).

Ql: Lake deposits associated with an ancient playa. Unit Ql is light yellowish brown (10YR 6/4 dry), very fine to medium sandy silt, medium dense to dense, iron oxide stained, massive, medium dense to dense, blocky, and with a densely jointed texture likely due to desiccation cracks. No fossils were encountered during this study. Ql deposits are shown photographs A and B on Plate 9.

Qoaf: Older alluvial fan deposits likely associated with regional aggradational depositional events associated with major Pleistocene glaciations. The unit is ubiquitous across the site in the near surface except for below elevation 426’ msl (old shore line) where it may exist at depth. These deposits are distal fan facies consisting of silty fine to very coarse sand with small to medium dense and massive gravels. This unit is currently correlated to similar fan deposits in the Ford Dry Lake region (WorleyParsons, 2010) where the unit exhibited multiple surface soils and paleosols that may be subdivided into additional members upon further study. As identified and correlated from the Ford Dry Lake area (WorleyParsons, 2010), the youngest soil is a minimum 12 to 20 kya old (soil designation S4), and a second common soil is estimated to be older than 20 kya at a minimum. The soil designations are described in the next section of this report.

Aeolian Units and Sand Migration Zones

Mapping current active areas of wind blown sand deposits in the Palen and Ford Dry Lake region is problemmatic because the Chuckwalla Valley during the latest Holocene has experienced a greatly reduced rate of wind blown sand migration and deposition compared to periods during the latest Pleistocene to late Holocene. Thus, many areas contain near surface sand deposits of latest Pleistocene to late Holocene age that are currently stabilized with vegetation and wind blown lag deposits. Most current active areas of wind blown sand transport continue to occur in the same regions since the latest Pleistocene however, evidence of the limits of relict dune deposits indicates that some zones have decreased in width. Evidence for a decrease in width of the aeolian sand migration corridor near the site is provided on Plates 2 and 3. Aeolian sand deposition and migration Zones I through IV represent a relative decrease in magnitude of sand transport and migration since the latest Pleistocene. The northeastern portion of Zone IV had received some aeolian sand transport and deposition sometime between the latest Pleistocene to mid to late Holocene that has subsequently diminished considerably. During the latest Holocene, aeolian sand supply is only sufficient to produce very limited areas of active aeolian deposition in Zone III. However, evidence of relict transverse dunes in Zone III indicate that this region experienced a higher aeolian sand flux in the past and likely during the latest to mid Holocene. Thus, the aerial extent of active dunes in the past covered a larger region than during the latest Holocene. Most areas now even within current sand migration corridors exhibit moderately to strongly stabilized dunes (Zones II through IV). Thus today, only limited areas within the active sand migration corridors exhibit extensive active dune systems (Zone I). Sand migration and deposition unit terms Qsa, Qsad, and Qsr (described below) attempt to discern relative magnitudes of the wind blown sand input and deposition within the region of the site (see Plates 1, 2 and 3).

Qsa: Unit Qsa represents active aeolian sand deposits that exhibit loose sand, leeward side avalanche faces, sand sheets (deposits from migrating ripples), and/or active coppice dunes with tails. Relative large regional areas dominated by unit Qsa are primarily located in Palen Dry Lake proper and at the eastern end of the Chuckwalla Valley at the north end of the Mule Mountains (Plate 1). The Palen Dry Lake dune field (proper) is one of a few BRGP dune fields considered to be active and thus continuing to grow (Dohrenwend, et. al., 1991). The Palen Dune field exists within and adjacent to Palen Dry Lake and exhibits abundant active dunes (barchan – concentric and transverse). Dominant graded scale resultant wind directions, based on the orientation of the dunes, arefrom the northwest and roughly parallel to the Chuckwalla Valley axis. Active barchan dunes in the Palen Dry Lake dune field migrate toward the east-south east (Dohrenwend, et. al., 1991). Partially and moderately stabilized Qsa deposits occur with the Project site within Zone II (Plates 2 and 3). Very limited areas of strongly stabilized unit Qsa occur in Zone III.

Unit Qsa is appropriate habitat for the Mojave fringe-toed lizard (MFTL) especially in areas that are partially stabilized with vegetation. Thus aeolian sand migration and depositional Zone II provides good habitat for MFTL due to the presence of abundant loose sand and scattered vegetation. Zone I near the site (Plates 2 and 3), which contains abundant exposures of unit Qsa lacks sufficient vegetation for robust MFTL populations due to a paucity of vegetation.

Photographs of unit Qsa are shown on Plates 4 (A), 7 (A and B) and 9 (A and B),

Qsad: Regions mapped as Qsad represent areas of active aeolian sand migration that varies from very week to moderately strong. Areas mapped as Qsad exhibit aeolian sand units Qsr and Qsa to varying degrees depending on the aeolian sand flux in the area. However, Qsa deposits within mapped Qsad mapped areas generally represent sand sheet deposits and not relatively large dunes with well defined avalanche faces. In other words, areas mapped as unit Qsad are primarily sand migration corridors forming sand sheet deposits (from migrating ripples) and coppice dunes across the existing topography.

It is clear that regions mapped as Qsad experienced higher aeolian sand input in the past that during the latest Holocene. The area mapped as Zone III on Plates 1 and 2 experienced limited aeolian sand migration which has led to the development of very limited areas of active aeolian sand deposition (unit Qsa) within the zone. Zone III experiences a moderately strong aeolian sand flux which has led to the creation of extensive areas of stabilized active wind blown sand deposits (unit Qsa). Many areas within mapped Qsad do not exhibit loose sand on the surface and fall under the definition of unit Qsr. This is the case for mapped aeolian migration and depositional Zones II and III (Plates 2 and 3).

Photographs of unit Qsad regions is shown on Plates 4 (A and B), 5 (A and B), 6 (A and B), 7 (A and B), and 8 (A and B).

Qsr: Relict aeolian sand sheet and degrading coppice dune sediments with very limited to no active sand transport or deposition. These sediments were deposited within wind transport and depositional areas during the Holocene or earlier that are no longer active. Extensive exposures of unit Qsr are identified within aeolian sand migration Zone III (Plates 2 and 3). Deposits consist of very fine to fine sand, strong brown (7.5YR 6/5 damp), massive to poorly bedded, and loose. Similar to unit Qal this unit commonly exhibits soil horizons in the upper 2 to 6 inches. During this preliminary study and based on limited data, soil profiles near surface exposures of unit Qsr exhibit mid to late Holocene ages. Unit Qsr is a common unit exposed on the surface and overlies unit Qal as a tabular sedimentary deposit averaging 4 to 8" thick in sand sheet areas (the most common). These deposits are typically strongly stabilized with grasses, creosote and wind generated very coarse sand to small gravel abrasion lag deposits.

Photographs of unit Qsr are provided on Plates 4 (B), 5 (A and B), 6 (A and B) and 8 (A).

Soil Profile Stratigraphy

For this study, a series of soil designations were determined during a similar aeolian sand study conducted near Ford Dry Lake (WorleyParsons, 2010). Until additional soil stratigraphy work is conducted at the PSPP site, these correlated soil designations will be utilized for this report. The soil profile designations are indented to provide a minimum age range for the soils and thus, minimum ages for the time of abandonment of the surface to the near surface soil deposits. A detailed soils profile analysis has not yet been conducted at the site, and the designated age ranges are minimum, (conservative) values for the soils identified. The soil designations and estimated age ranges are presented immediately below:

SOIL DESIGNATION	***ESTIMATED AGE AND DESCRIPTION***
S0	**<1000 years (1 ky)**
	No soil development.
S1	**1 to 3 kya**
	No desert varnish, weak surface gravel packing; 1/8" Av horizon, weak cambic Bw horizon typically to 3" depth (strong brown 7.5YR 5.6 dry), Entisol.
S2	**3 to 5 kya**
	Weak desert pavement and no to very slight desert varnish, slightly perceptible rubification, 1/16" thick carbonate rings along clast-surface contact, slight softening of clast surfaces from wind abrasion, 1/4" to1/2" thick gray to light yellowish brown (10YR 6/4 dry) Av and deepening Cambic Bw horizons (3 to 4 inches), minor secondary minerals, penetrative carbonate, Stage I-, slight hardening of B horizon.
S3a	**5 to 8 kya**
	Weak to moderately developed desert pavement and varnish, faint but clearly visible rubification, carbonate rings along clast-surface contact, softening of exposed clast surfaces from wind abrasion, ¼" pink (7.5YR 7/3 dry) Av horizon, Reddish Brown (5YR 7/3 dry) Bw horizon in parent fine grained sandy silt deposits to light yellowish brown (10YR 6/4 dry) to light brown (7.5YR 6/4 dry) in gravelly sand parent material, medium dense, blocky, iron oxide staining along vertical joints, Bwk horizon within 8" to 10" of surface, visible stage I- to I carbonate stringers-concentrations.
S3b	**8 - 12 kya**
	Moderate developed desert pavement, moderate desert varnish, carbonate rings along clast-surface contact, softening of clast edges

	by wind abrasion, ¼” pink (5YR 7/3 dry) Av horizon, 3” thick reddish yellow (5YR 6/6 dry) Bt with secondary clay, 5” thick light reddish brown (5YR 6/4 dry to damp) blocky Btk horizon with minimum stage I carbonate stringers, and horizontal Bk horizons.
S4	**12 - 20 kya**
	Moderate to well developed desert varnish and pavement, ¼” to 1 ½” pink (5YR 7/3 dry) Av horizon, Bt horizon: 4 to 8 inches thick, yellowish red (5YR 5/6 dry) thick, numerous vertical joints filled with Av material spaced at 3 to 8 inches and extending 3 to 6 inches deep, medium dense to dense, pinhole porosity, carbonate in upper 3 inches, secondary clay, clay ped bridging with blocky structure from 8 to 13 inch depth, in places Btk horizons as filaments to 1/8 inch diameter concretions in fine grained parent materials and crude parallel to surface carbonate lamellae in coarse grained parent materials, carbonate on underneath side of clasts, typically becomes very dense at 8 inches to 1 foot depth with continuation of the Bt horizon. Thus, lower limits of soil rarely fully excavated within site test pits (exceeds bottom of pit).
S5	**>20 kya but likely within latest Pleistocene**
	Well developed surface if not eroded away; Bt is yellowish red (2.5 - 7.5YR 5/6 dry, 4/6 moist, Btk with stage II carbonate, 1/4 to 1/2 inch diameter carbonate concretions, dense, blocky, secondary clay abundant in Bt horizon, soil profile a minimum of 2 feet thick.

Prevailing Wind Regimes in the Chuckwalla Valley Area (Resultant Drift Potential)

Annual and seasonal wind rose diagrams data from Blythe (ASOS data), which is located approximately 35 miles east of the Project site at the eastern most end of the Chuckwalla Valley near Blythe (Plate 1), indicate two dominant wind directions during typical years. During the Spring and Summer months, the strongest winds are from the south associated with monsoonal storm events. During the Fall and Winter, the strongest winds are from the north-north west associated with Pacific Ocean derived weather fronts. Determining the primary wind direction responsible for sand migration can be evaluated by geomorphic mapping of dune types, orientations, and locations, which is described later in the report, and by determining the Resultant Drift Potential (RDP) from appropriate wind data (Toar, 2004).

Muhs, et. al. (1995) determined the RDP for the Chuckwalla Valley to Blythe region for wind data collected at the Blythe Airport. Figure 2 below from Muhs, et. al., (1995) determined a RDP for the Blythe Airport that points nearly due east, parallel to the Chuckwalla Valley (left diagram).

The nearly due east resultant vector RDP for the Blythe Airport located near the eastern outlet of the Chuckwalla Valley (Palo Verde Mesa) is very consistent with field mapping data (this study) regarding the dominant direction of migrating sand (including long term field indicators such as ventifacts and dune alignment) in the Chuckwalla Valley axis corridor. This is discussed in more detail in the next section.

Major Local Aeolian Sand Migration Corridors

Major aeolian sand migration corridors were identified in the Chuckwalla Valley region by review of the literature, mapping areas of relatively young aeolian deposits, local dune structures, and observations of migrating sand during wind events. These are discussed in more detail below.

Review of the Literature

A number of published reports indentified the Chuckwalla Valley aeolian sand migration corridor (Dohrenwend, et al., 1991; Lancaster and Tchakerian, 2003; Muhs et al., 2003). These regional aeolian system studies indicated that the prevailing wind responsible for aeolian sand transport was from the northwest toward the southeast and locally controlled by topography (mountain ranges). Muhs et al. (1991) also identified the Palen Valley sand migration corridor located between the Coxcomb and Palen Mountains (Plate 1).

Mapping Young Aeolian Deposits

Aeolian deposits provide excellent data indicating the level of activity of local sand migration. Mapping in the Chuckwalla Valley with an emphasis on the Project area was conducted identifying aeolian deposits of various activity levels. Units Qsa, Qsad and Qsr provided criteria with a decreasing level of migrating and depositing aeolian sand activity respectively. The results of this mapping are provided on Plates 1, 2 and 3. Photographs of aeolian deposits in the region are also provided (see Plates 4 through 9). Qsa regions generally exhibit active sand ripples, active dunes and loose surficial sand at least a few inches thick. Mapped Qsad represents areas of active sand migration but exhibit a wide range of aeolian deposit types including active (minor Qsa areas) and inactive (Qsr). Qsr regions exhibit older aeolian deposits that are degrading or strongly stabilized.

Local Dune Structures (wind vectors)

Aeolian geomorphic structures provide excellent data regarding the dominant direction of aeolian sand transport and for different time scales. Prevailing wind direction indicators (wind vectors) for aeolian systems include sand ripples, dune types, coppice dune tails, and ventifacts. Each of these is discussed below.

Sand Ripples: Migrating aeolian sand ripples develop nearly perpendicular to the current wind. The ripples form nearly instantaneously and thus active surface ripples only provide information regarding the current or most recent strong wind direction.

Dune Types: Two primary types of dunes were identified during this study -- transverse and linear. These types of dunes are of substantial size that require decades to hundreds of years for their development (graded time) and thus provide excellent long term information regarding the prevailing wind directions (RDP). Transverse dunes, which include barchan dunes, generally form perpendicular to the regional prevailing winds (RDP) and linear dunes form within approximately 15 degrees from the prevailing wind or multiple dominant wind directions (mixed).

Coppice Dunes and Tails: Coppice dunes that develop at the base of shrubs provide excellent data prevailing wind data on a graded scale. In areas of active sand migration, coppice dune tails form on the leeward side of the coppice dune and thus provided excellent prevailing wind direction data and evidence of active sand migration in the area. In contrast, degraded to strongly degraded stabilized coppice dunes without evidence of coppice dune tails provide good data indicating a lack of active sand transport in a region. The identification of varied levels of coppice dune activity in the study area was a critical criteria for determining the level and direction of prevailing aeolian sand migration directions and magnitudes.

Ventifacts: Ventifacts represent surface rocks or outcrops that have been eroded by the abrasion associated with sand bearing wind. If the prevailing wind is form a consistent direction, then rocks on the surface can sometimes form erosional structures roughly parallel to the wind. Internal structure of the exposed ventifact rock can place strong controls as well on the orientation of the abrasion structure. Ventifacts providing useful prevailing long term wind direction utilized in this report were identified on late Pleistocene alluvial fan surfaces and composed of homogeneous clasts like non-foliated quartzite.

Observations of migrating sand during wind events

Field observations during storm wind events associated with a typical winter major storm from the Pacific Ocean were conducted on December 22 and 23, 2009. Migrating aeolian sand and a fine grained dust cloud were observed that provided direct evidence of aeolian sand migration in the Chuckwalla Valley. Aeolian sand was observed migrating at various locations that is consistent with the wind vectors, dune structures, and major aeolian sand migration corridors shown on Plates 1, 2 and 3. It was observed that aeolian sand was transported a minimum of 6 feet above the ground surface and had no difficulty migrating across an entrenched dirt road within the Chuckwalla Valley axis between the Palen and Ford dry lake regions.

Aeolian sand and a fine grained dust cloud that rose hundreds of feet into the air was also observed travelling down the axis of the Chuckwalla Valley from Palen Dry Lake and crossed Interstate Highway 10 approximately 3 to 4 miles west of the Wiley Well rest stop (Plate 1). This same dust cloud was also observed to slowly migrate toward the north and head across the center of Ford Dry Lake proper as the winds died down in the late afternoon.

Identified Aeolian Sand Migration Corridors in the Chuckwalla Valley Region

Three aeolian sand migration corridors have been identified within the Chuckwalla Valley region. The dominant sand migration direction within the corridors is toward the east and south and essentially parallel to existing valley axis. Thus the sand migration is controlled both by the RDP and topographically by local mountain ranges and valleys. The identified local sand migration corridors in the Chuckwalla Valley area include

- The Dale Lake – Palen Dry Lake – Ford Dry Lake (north of Mule Mountains) sand migration corridor. The dominant sand migration is toward the southeast to east. This sand migration corridor is shown as PDL-Chuckwalla Valley on Plate 1.

- The Palen Valley – Palen Dry Lake sand migration corridor. Sand migrates toward the south between the Coxcomb and Palen Mountains. The vast majority of the sand migrates along the eastern side of the Palen Valley particularly northeast of Palen Dry Lake and the southwest side of the Palen Mountains. Migrating sand from this corridor merges with sand from the PDL-Chuckwalla Valley migration corridor along the southwestern and southern end of the Palen Mountains.

- The Palen Pass – Palen-McCoy Valley sand migration corridor. Sand migrates toward the south from Palen Pass to the eastern side of Ford Dry Lake. The vast majority of the migrating sand is along the eastern side of the Palen-McCoy Valley.

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Regional Aeolian Sand Sources

There are numerous sources of aeolian sand within the Chuckwalla Valley. In the BRGP west of the Colorado River, the primary aeolian sand sources are ephemeral drainages soon after they flow, playa lakes, existing active dune fields within sand migration corridors, and older aeolian deposits. These are discussed below.

Drainage Aeolian Sand Source

After a wash flows it exposes potential sand for wind entrainment at the surface. Strong winds within just a few strong wind storms subsequent to drainage flow will entrain most of the available sand (saltation) and begin to move the sand out of the channel. It does not take long for the fresh fluvial sands to form a protective cap composed of very coarse sand and/or gravel as the finer aeolian sands are removed by the wind. After the gravel cap forms, very little additional sand is entrained by the wind from the wash until it flows again. Thus, drainages that flow often will produce substantially more aeolian sand than washes that flow infrequently.

Playa Lakes

Eroding playa lake area sediments, many of which also contain older dune deposits, are a major potential source of sand for dune systems due to wind abrasion (see Photograph B on Plate 8). Playa lakes will produce an increased rate of aeolian sand soon after they dry up if in-filled with water from nearby washes and from rain falling on the lake bed surface. Variations in wind directions or strength, or changes in vegetation cover can lead to changes of aeolian sand flux as well. Playa lakes are generally located within the center of basins and bounded by mountain ranges thus causing them to experience some of the strongest prevailing winds in the region. In the region of the site linears, both the Palen and Ford Dry Lakes are aeolian sand contributors.

Active Dune Fields

Active dune fields, especially if located within a major aeolian sand migration corridor will simply be a sand source for dune systems in the direction of the prevailing wind. Thus, once sand reaches a major aeolian sand migration corridor, it will begin to migrate within the corridor.

Older Aeolian Deposits

If older dune deposits are not maintained by new aeolian sand and also do not become sufficiently stabilized (vegetation, wind abrasion lag), the can fall victim to wind abrasion that allows the sand grains to once again be entrained by the wind. This was easily observed in older dune deposits throughout the Chuckwalla Valley within mapped units Qsr and Qsad.

Local Aeolian Sand Sources (Providence Study

The Palen Dune field exists within and adjacent to Palen Dry Lake and exhibits abundant active dunes (barchan – conscentric and transverse). Dominant graded scale resultant wind directions based on the orientation of the dunes is from the northwest and roughly parallel to the Chuckwalla Valley axis. Active barchan dunes in the Palen Dry Lake dune field migrate toward the east-south east (Dohrenwend, et. al., 1991). Most of the sand feeding the Palen Dry Lake dunes is derived from the west along the Dale Dry Lake to Palen Dry Lake sand migration corridor (Plate 1). In the easternmost Palen Dry Lake region, sand migrating down the Palen Valley merges with the Dale Dry Lake-Palen Dry Lake sand migration corridor. However, based on aerial image analysis and field mapping, the sand migrating within the Palen Valley does not reach the Palen Solar Power Project site.

Sources of aeolian sand for the MFTL habitat dunes (Zones II and III on Plates 2 and 3) is dominated by wind blown sand migrating down the Dale Dry Lake to Palen Dry Lake sand migration corridor (PDL-Chuckwalla Valley on Plate 1). The PDL-Chuckwalla Valley sand migration corridor is also the dominant source of sand for the dunes shown in Zones II and III located immediately southeast of the property. A minor local sand source contributing to the PDL-Chuckwalla Valley migration corridor is from erosion of older deposits within Palen Dry Lake proper (see Photograph B on Plate 8).

Based on limited data, it is likely that the site drainages are a minor source of aeolian sand to the local dunes both within the property and to a much lesser extent immediately to the southeast of the property.

Preliminary Evidence of the Temporal and Spatial Behavior of Ancient Playa Lakes

A preliminary evaluation of the temporal (time) and spatial (location) of ancient playa lakes within the Palen basin was conducted during this study. The evidence includes evaluation of sedimentary deposit types, soil profile ages and elevations. Key site locations utilized in this preliminary analysis are provided on Plate 2. Evidence for lake stands is provided by the presence of lacustrine deposits (unit Ql) near the surface. In contrast, the identification of Quaternary Older Alluvial Fan deposits (unit Qoaf) indicates that a playa lake had not existed in that area since the deposition of the local fan deposit. Soil profiles evaluated for near surface Qoaf and Ql deposits provided approximate ages for the deposits. Locations for the sites were determined with a hand held GPS unit and, once plotted on Google Earth, allowed for the determination of the site elevation. Thus, all elevations utilized in this ancient lake analysis are from Google Earth.

The combination of type of unit, age, and location allows for the evaluation of the timing and location of ancient lake shore lines within the Palen basin. Preliminary evidence indicates that unit Qoaf exhibiting an S4 soil (minimum age of 12 to 20 kya) exists along the southern margin of Palen Dry Lake at an elevation of 428' msl (see sites 24P and 29P on Plate 2). This evidence indicates that a lake high stand within Palen basin has not existed above elevation 427' msl since the latest Pleistocene. Ancient playa lake deposits (unit Ql) were identified at elevations of 426' msl exhibiting soil profiles of S3a and S4 (see sites 4P and 28P on Plate 2 respectively). This evidence indicates that an ancient playa lake within the Palen basin has likely not occurred above elevation 426' since the latest to mid Holocene. Site 25P at elevation 425' (Plate 2) exhibited Ql deposits with no to very weak near surface soil development indicating that playa lakes may have occurred in the Palen basin to elevation 425 msl during the late Holocene. A test pit at site 25P to a depth of approximately 1 foot indicated the presence of 3 to 5 individual ephemeral lake deposits.

Based on Google Earth, the sill (highest elevation for a basin) for the Palen basin is located to the east south of the southern end of the Palen Mountains at an elevation of approximately 423 to 424' msl. This elevation is consistent (within error margin of Google Earth) with the data provided above that late Holocene ephemeral playa lakes rose to an elevation no higher than 425' msl.

CONCLUSIONS

AEOLIAN SYSTEM

The Chuckwalla Valley is a region of active aeolian sand migration and deposition but at a magnitude substantially less that it had experienced during dune aggradational events since the latest Pleistocene. In general, major local sand migration corridors utilized in the past are currently utilized but have decreased in width within the area of the Project. This indicates that the aerial extent of aeolian activity in recent times is less that it once was during regional dune aggradational events. This can be seen on Plates 2 and 3, where unit Qsr (relict dune fields) extends into sand migration Zone IV that is currently receiving very limited to no aeolian sand input during the latest Holocene. In addition, Zone III is dominated by relict dune deposits (Qsr) and only exhibits minor areas of active loose surficial sand indicating that active sand migration in this zone is low during the latest Holocene. Sand migration within Zone II is moderately strong and active sand deposition appears to take place in areas of older dune fields.

Based on the existing data, preliminary estimates of the relative magnitude of aeolian sand sources and migration in the region of the Project includes include the following (see Plates 2 and 3 for the locations of sand migration Zones I through IV):

- Most sand movement occurs within the Project site takes place in zone II; that is, sand movement increases from the southwest toward the northeast. Wind blown sand does not occur within the southwestern portion of Zone IV, but a small amount may take place near the Zone III/IV border.

- Aeolian sand migration takes place within Zone III (which exhibits very limited areas of active sand sheet deposits), but is relatively low.
- Sand migration magnitude within Zone II is moderately strong with the dominant source of sand coming from the PDL-Chuckwalla Valley sand migration corridor. The contact between Zones II and III is relatively sharp over a distance of a couple hundred feet, and thus, its boundary is fairly well defined.
- Natural aeolian sand migration in Zones II and III will be obstructed by development of the PSPP and potentially may slowly adversely impact MFTL habitat immediately to the southeast of the property. The impact on sand deposits toward the southeast of the decrease in sand migration through the proposed footprint will likely be evident only after decades.
- A minimum of 80% of the aeolian sand migration within the PDL-Chuckwalla sand migration corridor occurs within Zone I, which is located northeast of the PSPP boundary.
- Palen Dry Lake proper is a relatively minor contributor to Zone II within and immediately southeast of the Project site.
- The north-to-south Palen Valley sand migration corridor is not a source of sand for dunes within the PSPP site.
- Local drainages within the Project site appear to be a very minor aeolian sand source but the drainages do not produce sand at a rate that would by itself support active sand dunes sufficient for MFTL habitat. Thus, a decrease of drainage flow within the Project site after construction will not adversely affect identified MFTL habitat outside of Project site after construction.
- The natural ground surface between active drainages (intra-washes) is a very minor source of aeolian sand. These regions are not geologically active and are either vegetated or exhibit a protective gravel wind lag cap resistant to additional wind abrasion.

Comparison of the proposed construction design and identified MFTL locations within the Project site (EDAW, 2009; see Plate 2 and 3), shows that MFTL habitat will be adversely impacted by the proposed development. Current evidence indicates that the aeolian sand source for the MFTL habitat sand deposits within Zones II and III within the Project site property will likely remain for decades into the future.

Aeolian sand migration was directly observed to occur across low profile man made structures, rough alluvial fan surfaces, and very hummocky and vegetated topography within the sand migration corridors. Aeolian sand migration across the linears will occur during the lifetime of the Project from both the northerly and westerly prevailing winds. Therefore, a low profile access road as proposed in the Project design would not adversely affect aeolian sand transport toward the south and east, as wind blown sand was directly observed to easily transect such structures and to travel at heights of at least six feet.

ANCIENT PLAYA LAKES IN PALEN BASIN

Preliminary evidence indicates that:

- A lake high stand (the highest elevation) within Palen basin has not exceeded elevation 427' msl since the latest Pleistocene.

- An ancient playa lake within the Palen basin has likely not occurred above elevation 426' since the latest to mid Holocene.

- Ephemeral playa lakes may have occurred in the Palen basin to elevation 425 msl during the late Holocene.

- The sill (highest elevation of the basin) for the Palen basin is likely at an elevation of approximately 423 to 424' msl.

This preliminary evidence indicates that an ancient lake shoreline may have existed in the northeastern corner of the property since the latest Pleistocene and into the Holocene. Preliminary geologic data suggests that individual lake stand deposits are only 1 to 3 inches thick suggesting that the lakes did not persist for hundreds of years, but more likely on the order of from several years to a few decades.

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APPENDIX A

GLOSSARY OF TERMS

AEOLIAN: Wind Blown. Aeolus was ruler of the winds in Greek mythology.

AEOLIAN DEPOSITS: Sediments transported and subsequently deposited by moving air.

AGGRADATION: An increase in land elevation due to the **DEPOSITION** of sediment. Aggradation occurs in areas in which the supply of sediment is greater than the amount of material that the system is able to **TRANSPORT**. For example, sand dunes will undergo aggradation if the supply of aeolian sand is greater than the flux of sand out of the system.

ALLUVIAL DEPOSITS: Sediments deposited by flowing water.

BAJADA: An alluvial plain formed along the flanks of a mountain by the coalescing of several alluvial fan deposits. Thus numerous alluvial fans each emerging from a individual valley within the mountain range merge together to form a relatively smooth surface referred to as a bajada. Also see piedmont surface.

COPPICE DUNES: Vegetated sand mounds that are commonly scattered throughout sand sheets in semiarid regions where shrubs and blowing sand are abundant. Any shrub sticking up into the airborne stream of sand is an impediment to the flow, and the resulting turbulence and speed losses cause sand grains to settle out on the downwind side of the shrub and around its base. Coppice dunes range from about 0.5 to 3 m in height and from 1 to 15 m in breadth. Within any given field of coppice dunes, however, the dune size tends towards uniformity. Under certain conditions, individuals or clusters of dunes can become very large and are called vegetation mounds. Because the sand accumulates in piles around the plants and is swept from the surfaces between the plants, a hummocky, rough topography develops that is very different from the smooth, flat, and locally gentle undulatory surfaces of sand plains that are devoid of vegetation and are frequently barren, typically have firm, trough like, scoured surfaces of hard-packed soil, with thin patches of rippled sand or granules (Desert Processes Working Group).

Most active coppice dunes in the Chuckwalla Valley region exhibit “coppice tails” on the leeward side (downwind side) of the coppice mound at the base of the plant. The tails are triangular in shape and with the wide end attached to the plant sand mound and points (narrows) downwind from the plant. The coppice tails are generally 3-inches to 3 feet long and provide excellent wind vector data for approximately graded time (past 1 to 10 years). In addition, a lack of active coppice tails and degraded and/or vegetated coppice mounds at the base of plants is an excellent indicator that sand is not currently migrating within that area.

CORRIDOR SYSTEM (AEOLIAN): An aeolian corridor system pertains to aeolian sand pathways extending for tens of miles and involving numerous subbasins within the Mojave Desert. Regarding the site, a number of studies have identified the Dale Lake to Mule Mountains sand corridor system that allows wind blown sand to travel approximately 70 miles toward the east via topographic valleys and playa lake basins (Palen and Ford Dry Lakes). Our study has identified that the simple single sand corridor is from Dale Lake to the north end of the Mule Mountains is also fed by considerable sand from north to south valleys as well (Palen Valley to Palen Dry Lake and the Palen-McCoy Valley which feeds the eastern end of Ford Dry Lake).

CYCLIC TEMPORAL AND SPATIAL SCALE: Cyclic scale includes a temporal scale involving periods of 10^3 to 10^5 years and spatial scale corresponding to that of large dune field areas

(Lancaster, 1995). For this study, Cyclic scale involved the formation of the most of the larger dunes within the Chuckwalla aeolian system that took thousands of years during major aggradational events of the latest Pleistocene and mid Holocene.

GRADED TEMPORAL AND SPATIAL SCALE: Graded scale time is a temporal scale involving periods of 1 to 10^2 years and particularly concerns the dynamics and morphology of dunes, which tend towards an actual or partial equilibrium with respect to rates and directions of sand movements generated by surface winds (Lancaster, N., 1995). Aeolian structures or deposits that may have formed or existed between 1 to less than approximately 1000 years is considered to have formed during graded time. For example within this study, graded time structures include small active dunes and medium to relatively larger size active coppice dunes and their respective tails. In addition, graded special scale involves aeolian processes as the migration of individual dunes within a dune system.

HOLOCENE EPOCH: The Holocene is a geological epoch which began approximately 11,700 years ago (10,000 ^{14}C years ago). According to traditional geological thinking, the Holocene continues to the present.

INSTANTANEOUS TEMPORAL AND SPATIAL SCALE: Instantaneous temporal and spatial scale involves very short to instantaneous periods of time and small areas. Some examples of aeolian structures that form within instantaneous scale involve the formation of sand ripples that can develop in a few minutes and very small coppice dune tails behind shrubs.

INTERDUNE: Interdune areas of the desert floor occur between individual dunes in fields. Closed interdune areas may be poorly drained, contain playas and are typically flat. Where dry and floored by sandy sediment, they have many of the same characteristics as sand sheets. If near-surface moisture is present, interdune areas may contain grasses, shrubs, trees, or even settlements. Interdune areas range in size from a few to tens of square kilometers. In any given locality, the sizes and shapes of the interdune areas are similar, as are those of the intervening dunes

LEE (leeward side of a dune): The leeward side of a sand dune is down wind from the dominant resultant wind direction primarily responsible for its form. The lee side of an individual dune exists between the crest and the base of the avalanche face. On active dunes (Qsa), many active dunes exhibit a free avalanche face where sand sediment is deposited near the angle of repose. (related term – Stoss)

LINEAR DUNES: One of the most common dune types, linear dunes are generally straight to irregularly sinuous, elongate, sand ridges of loose, well-sorted, very fine to medium sand. The straight varieties are often called "sand ridges," and the sinuous varieties are often called "seifs." The lengths of individual dunes, which are much greater than the widths, can range from a few meters to many kilometers. They form in at least two environmental settings: where winds of bimodal direction blow across loose sand, and also where single-direction winds blow over sediment that is locally stabilized, be it through vegetation, sediment cohesion or topographic shelter from the winds. The latter is likely the mechanism of the linear dunes just east of the Genesis Solar Power Plant array.

Linear dunes have formed in areas now characterized by wide ranges of wind speeds and directions. Most are probably "fossil" dunes formed under more vigorous wind regimes during Pleistocene climatic conditions. Since then, wind regimes have apparently become less intense, although wind directions are apparently similar. Thus, where linear dunes are active today, they are commonly being modified into compound or complex features by the addition of secondary dunes. Nonetheless, the long axes of linear dunes are aligned generally within 15° of the prevailing wind or with the resultant drift direction of the local winds. The sinuosity and alternate slip faces develop because crosswinds change direction and alternately shepherd the sand to each side of the dune axes. Long standing opinion on linear dune migration is parallel and along the downwind axis of the dune. However, new evidence is emerging that indicates that linear dunes move oblique to the axis of the dune in the primary direction of the resulting wind drift direction which is often approximately 15° oblique to the dune axis.

PARABOLIC DUNES: In plan view, these are U-shaped or V-shaped mounds of well-sorted, very fine to medium sand with elongated arms that extend upwind behind the central part of the dune (opposite of Barchan dunes). Slip faces occur on the outer (convex) side of the nose of the dune and on the outside slopes of its elongated arms.

Parabolic dunes are always associated with vegetation--grasses, shrubs, and occasional trees, which anchor the trailing arms. In inland deserts, parabolic dunes commonly originate and extend downwind from blowouts in sand sheets only partly anchored by vegetation. They can also originate from beach sands and extend inland into vegetated areas in coastal zones and on shores of large lakes. Coppice dunes are commonly associated with parabolic dune fields. They are frequently found on sand sheets and on and around larger parabolic dunes.

Most parabolic dunes do not grow to heights greater than a few tens of meters except at their forward portions, where sand piles up as its advance is halted or slowed by surrounding vegetation. Parabolic dunes, like crescentic dunes (i.e. barchan), are characteristic of areas where strong winds are unidirectional. Although these dunes are found in areas now characterized by variable wind speeds ranging from low to high, the effective winds associated with the growth and migration of both the parabolic and crescentic dunes probably are the most consistent in wind direction. Some parabolic dunes exist south of Wiley Well rest stop (Plate 1).

PIEDMONT SURFACE: The sediment debris apron that occurs between the mountain and valley floor. The piedmont slope characteristically slopes away from the mountains. Flow directions in the piedmont slope are transverse to flow directions in the adjacent valley floor. The piedmont slope is subdivided into the five types listed below based on their morphology and relative age. Although morphologically distinct, each landform has formed by similar processes. These include debris flows (fluidized slurries that flow downslope following intense downpours), grain flow (gravity-driven grain-to-grain downslope movement of sediment), and traction currents (sediments entrained by streams or sheetflows). The difference between the five groups center on their stage of development; active construction, e.g. alluvial fan, bajada or wash, vs. dissection and destruction, e.g. older alluvial fan. If the sediment landform is undistinguished, it is reported as an undifferentiated deposit.

PLEISTOCENE EPOCH: The Pleistocene is the epoch from 2.588 million to ~12,000 years before present (BP) covering the world's recent period of repeated glaciations. The Pleistocene Epoch is subdivided into Early (2.6 Ma to 781 kya), Middle (781 to 126 kya) and Late (126 to 12 kya). Time boundaries for the Pleistocene Epoch are still debated. Many publications reference the beginning of the Pleistocene at 1.6 Ma; however, this earlier date does not impact the findings in this report. Within this report the term Latest Pleistocene is considered the last 50 to 60 kya of the late Pleistocene described above.

SAND SHEETS: Sand sheets (or plains) are flat or gently undulatory broad floors of tabular wind blown sand deposits derived from accumulating sand ripple migration. The tabular deposits generally range in thickness from a few centimeters to a few meters). Some sand sheets, as in the southwestern U.S., are local deposits that extend only a few square kilometers in and around dune fields, where they are exposed on interdune floors and form the aprons or trailing margins of dune fields and along sand migration corridors.

Sand sheet deposits are composed of gently inclined or nearly horizontal layers, each less than about a centimeter thick, of coarse silt and very fine to medium sand separated by layers, one grain thick, of coarse sand and granules. Unlike dune sand, the unconsolidated sand and granules are closely packed and firm under foot. The surface is protected by a wind abrasion lag, one grain thick, of the coarsest particles that can be shifted by the wind, ranging from coarse sand to pea-size gravel. In any one place, however, the sizes of the lag particles are remarkably uniform, and the lag may be so closely packed that it forms a miniature desert pavement. In the Chuckwalla Valley, the wind abrasion lag often contains small gravel that may have been derived from burrowing animals moving coarser grained alluvial deposits containing gravel to the surface in the past (McAuliffe and McDonald, 1995). The existence of a wind abrasion lag containing gravel from underlying alluvial units suggests that the surface is a minimum of a few thousand years old in order to provide sufficient time for burrowing animals to mix the near surface units over a relatively large area.

Sand sheets in themselves indicate little about wind direction regimes, but the particle size of sand and gravel lag on ripple surfaces seems dependent on the strength of the winds in any given locality. Inactive sand sheet deposits near and at the surface however do provide evidence of past wind sand migration corridors.

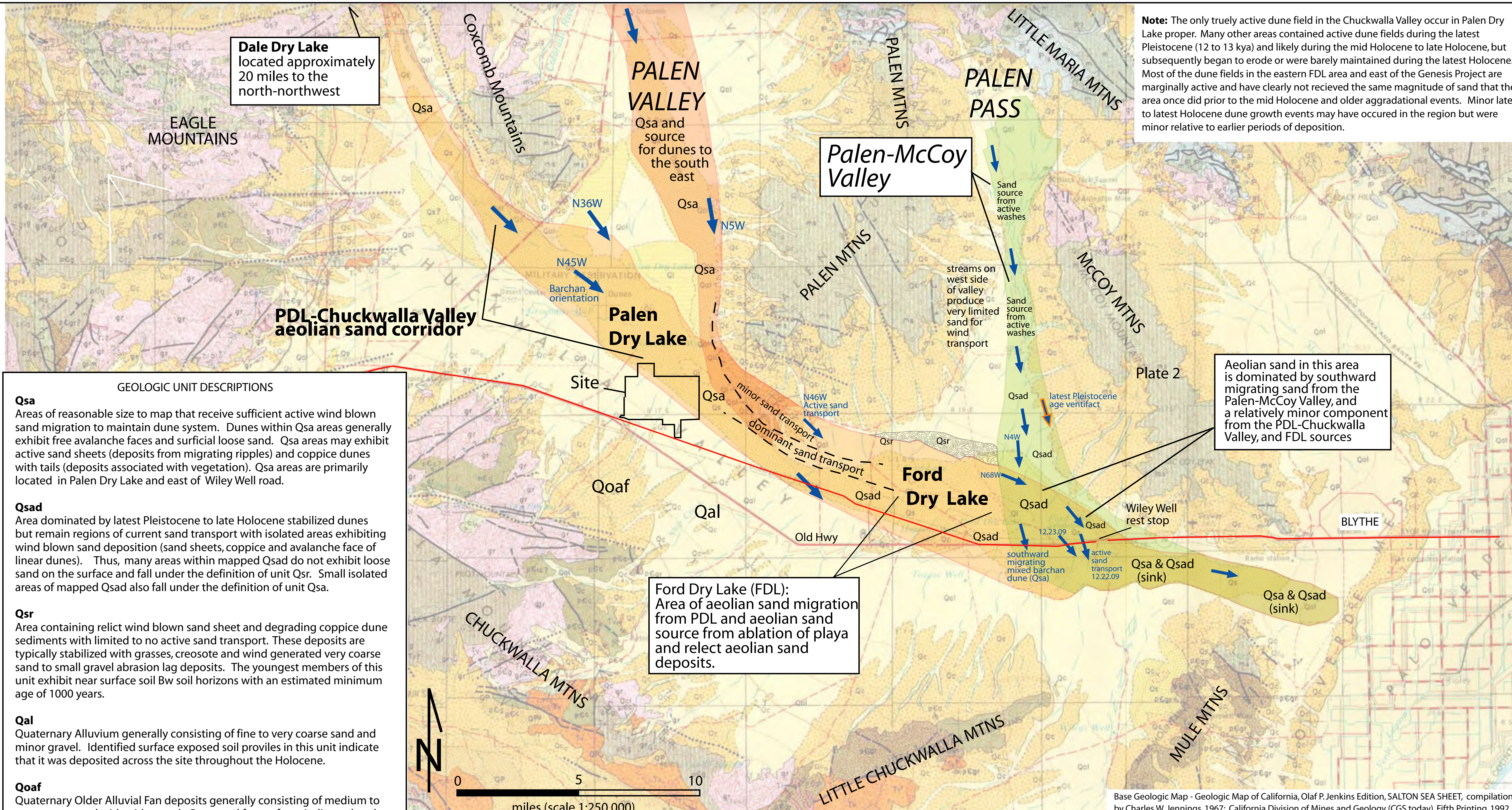
STABILIZED DUNES: Sand dunes that are unable to migrate due to vegetation growth on the dune itself are considered stabilized dunes and also referred to as vegetated dunes. These types of dunes often develop due to insufficient aeolian sand input to the dune to allow for growth and migration. Within this study, dune areas mapped as Qsad and Qsr are dominated by stabilized dunes.

STOSS: The stoss side of the dune points toward the direction the dominant resultant wind responsible for the primary dune form originates. The stoss side exists between the toe and the crest of the dune. Thus, the stoss side of a dune is on the upwind side (related term – Lee).

VENTIFACTS: Rocks that have been abraded, pitted, etched, grooved, or polished by wind-driven sand. Ventifacts typically occur on gravel size rocks exposed on the surface to sand bearing wind. Common surfaces containing ventifacts within the Chuckwalla Valley consist of wind abrasion lag deposits and abandoned alluvial fan surfaces. Ventifacts are identified by rounded edges and a soft feel on the gravel side exposed to the atmosphere. Ventifact forms provide information regarding the prevailing wind direction. Triangular faceted ventifacts are believed to indicate multidirectional prevailing wind directions, and mono-direction “linear” ventifacts provide evidence of a dominant uni-direction resultant drift wind direction. However, prevailing wind evaluation of ventifacts should be conducted on homogeneous clasts such as quartzite that does not exhibit internal structures that may produce differential mechanical erosion in orientation close to perpendicular to prevailing wind directions.

Plates

Note: The only truely active dune field in the Chuckwalla Valley occur in Palen Dry Lake proper. Many other areas contained active dune fields during the latest Pleistocene (12 to 13 kya) and likely during the mid Holocene to late Holocene, but subsequently began to erode or were barely maintained during the latest Holocene. Most of the dune fields in the eastern FDL area and east of the Genesis Project are marginally active and have clearly not recieved the same magnitude of sand that the area once did prior to the mid Holocene and older aggradational events. Minor late to latest Holocene dune growth events may have occured in the region but were minor relative to earlier periods of deposition.



Base Geologic Map - Geologic Map of California, Olaf P. Jenkins Edition, SALTON SEA SHEET, compilation by Charles W. Jennings, 1967; California Division of Mines and Geology (CGS today), Fifth Printing, 1992.

GEOLOGIC UNIT DESCRIPTIONS

Qsa
Areas of reasonable size to map that receive sufficient active wind blown sand migration to maintain dune system. Dunes within Qsa areas generally exhibit free avalanche faces and surficial loose sand. Qsa areas may exhibit active sand sheets (deposits from migrating ripples) and coppice dunes with tails (deposits associated with vegetation). Qsa areas are primarily located in Palen Dry Lake and east of Wiley Well road.

Qsad
Area dominated by latest Pleistocene to late Holocene stabilized dunes but remain regions of current sand transport with isolated areas exhibiting wind blown sand deposition (sand sheets, coppice and avalanche face of linear dunes). Thus, many areas within mapped Qsad do not exhibit loose sand on the surface and fall under the definition of unit Qsr. Small isolated areas of mapped Qsad also fall under the definition of unit Qsa.

Qsr
Area containing relict wind blown sand sheet and degrading coppice dune sediments with limited to no active sand transport. These deposits are typically stabilized with grasses, creosote and wind generated very coarse sand to small gravel abrasion lag deposits. The youngest members of this unit exhibit near surface soil Bw soil horizons with an estimated minimum age of 1000 years.

Qal
Quaternary Alluvium generally consisting of fine to very coarse sand and minor gravel. Identified surface exposed soil proviles in this unit indicate that it was deposited across the site throughout the Holocene.

Qoaf
Quaternary Older Alluvial Fan deposits generally consisting of medium to very coarse sand with with gravel. Preserved fan surfaces indicate that the surface exposed upper members of the unit are latest Pleistocene (12 to 25ky). These deposits represent medial to distal fan facies near the property.

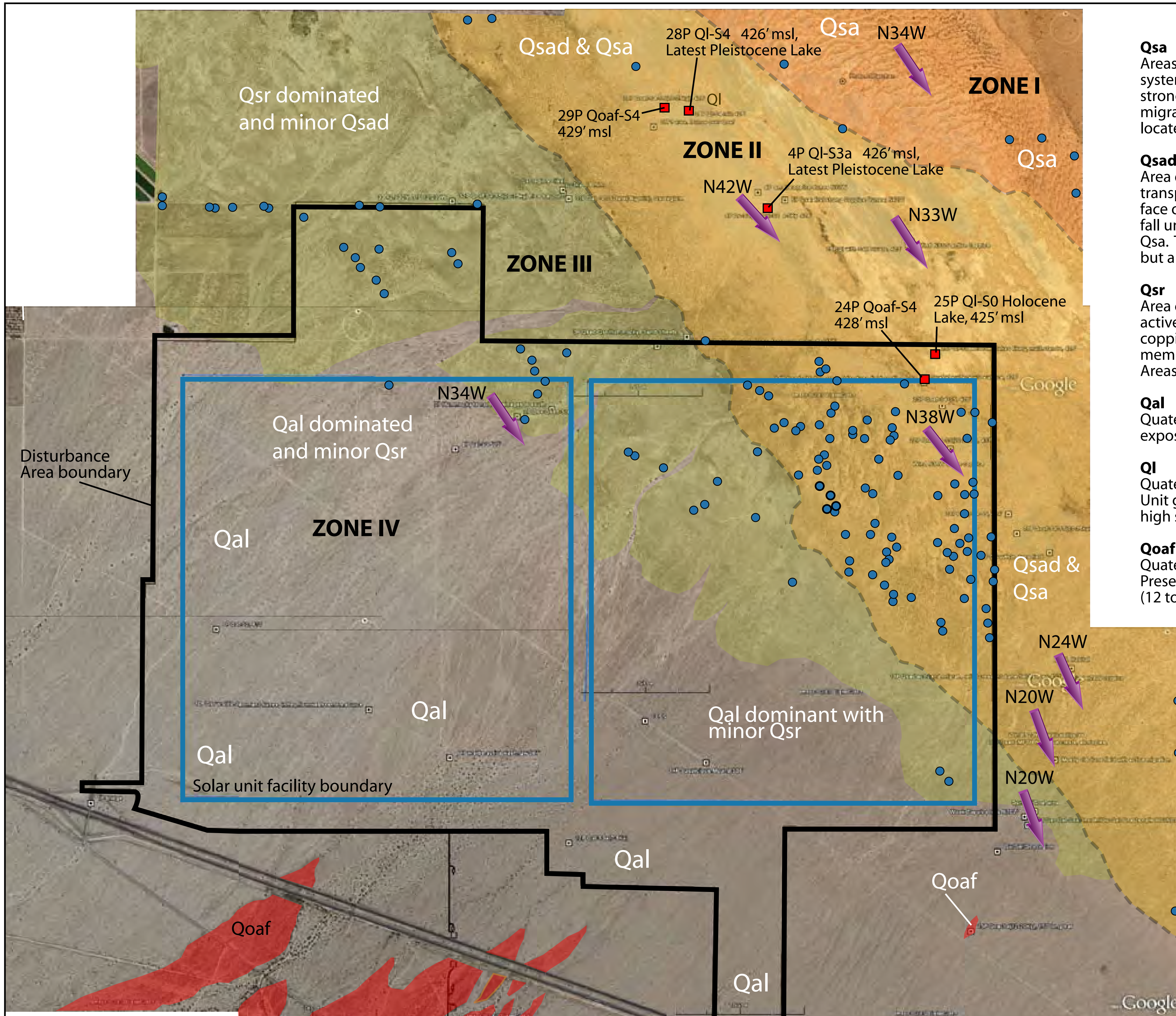
Approximate current limits of the active wind sand transport corridor from the Palan Dry Lake region down the Chuckwalla Valley. Dominant resultant sand movement toward the east.

Approximate current limits of the active wind sand transport corridor from the Palen Pass region down the Palen and McCoy Mountain Valley. Dominant resultant sand movement toward the south-southeast.

N20W

Wind direction vector measured in the field. Directions based on coppice tails (graded scale of 1 to 10 years), barchan and Linear dunes (cyclic scale - thousands of years), and ventifacts in rocks on late Pleistocene surfaces. Note, vector directions were not obtained from instaneously forming ripple directions, however, active ripples were very generally very consistent with older wind direction indicators. Orientation indicates direction the wind is from.

PALEN SOLAR I, LLC	Map by Miles D. Kenney PhD, PG
Generalized Aeolian Sand Migration Corridors and Depositional Areas, Chuckwalla Valley, California	M. Kenney — 2/11/2010
	Plate 1



GEOLOGIC UNIT DESCRIPTIONS

Qsa
Areas of reasonable size to map that receive sufficient active wind blown sand migration to maintain dune system. Dunes within Qsa areas generally exhibit free avalanche faces, surficial loose sand. and are not strongly stabilized with grasses and creosote. Qsa areas may exhibit active sand sheets (deposits from migrating ripples) and coppice dunes with tails (deposits associated with vegetation). Qsa areas are primarily located in Palen Dry Lake and east of Wiley Well road.

Qsad
Area dominated by latest Pleistocene to late Holocene stabilized dunes but remain regions of current sand transport with isolated areas exhibiting wind blown sand deposition (sand sheets, coppice and avalanche face of linear dunes). Thus, many areas within mapped Qsad do not exhibit loose sand on the surface and fall under the definition of unit Qsr. Small isolated areas of mapped Qsad also fall under the definition of unit Qsa. Thus, Qsad regions have experienced a decrease in the aeolian sand magnitude during the late Holocene but also exhibit a current aeolian sand flux sufficient to maintain limited areas of Qsa dunes.

Qsr
Area containing relict wind blown sand sheet and degrading coppice dune sediments with very limited to no active sand transport. These deposits are typically stabilized with grasses, and creosote, exhibit degrading coppice dunes, and wind generated very coarse sand to small gravel abrasion lag deposits. The youngest members of this unit exhibit near surface soil Bw soil horizons with an estimated minimum age of 1000 years. Areas of very limited extent of loose aeolian sand deposits can occur within areas mapped as Qsr.

Qal
Quaternary Alluvium generally consisting of fine to very coarse sand and minor gravel. Identified surface exposed soil proviles in this unit indicate that it was deposited across the site throughout the Holocene.

Ql
Quaternary Playa Lake (lacustrine) deposits consisting of massive very fine to medium sandy silt and clay. Unit generally interbedded with aeolian sand members. Late Holocene lakes may have reached elevation high stands of 425' msl but likely not higher than elevation 426' msl based on preliminary data.

Qoaf
Quaternary Older Alluvial Fan deposits generally consisting of medium to very coarse sand with with gravel. Preserved fan surfaces indicate that the surface exposed upper members of the unit are latest Pleistocene (12 to 25ky). These deposits represent medial to distal fan facies near the property.

SYMBOL DESCRIPTIONS

N42W — Wind direction vector measured in the field. Directions based on coppice tails (graded scale of 1 to 10 years), barchan and Linear dunes (cyclic scale - thousands of years). Note, vector directions were not obtained from instaneously forming ripple directions, however, active ripples were very generally very consistent with older wind direction indicators. Orientation indicates direction the wind is from.

Approximate location of Mojave Fringe-Toad Lizard Observations from Bioligical Technical Report (ADAW AECOM, August 2009).

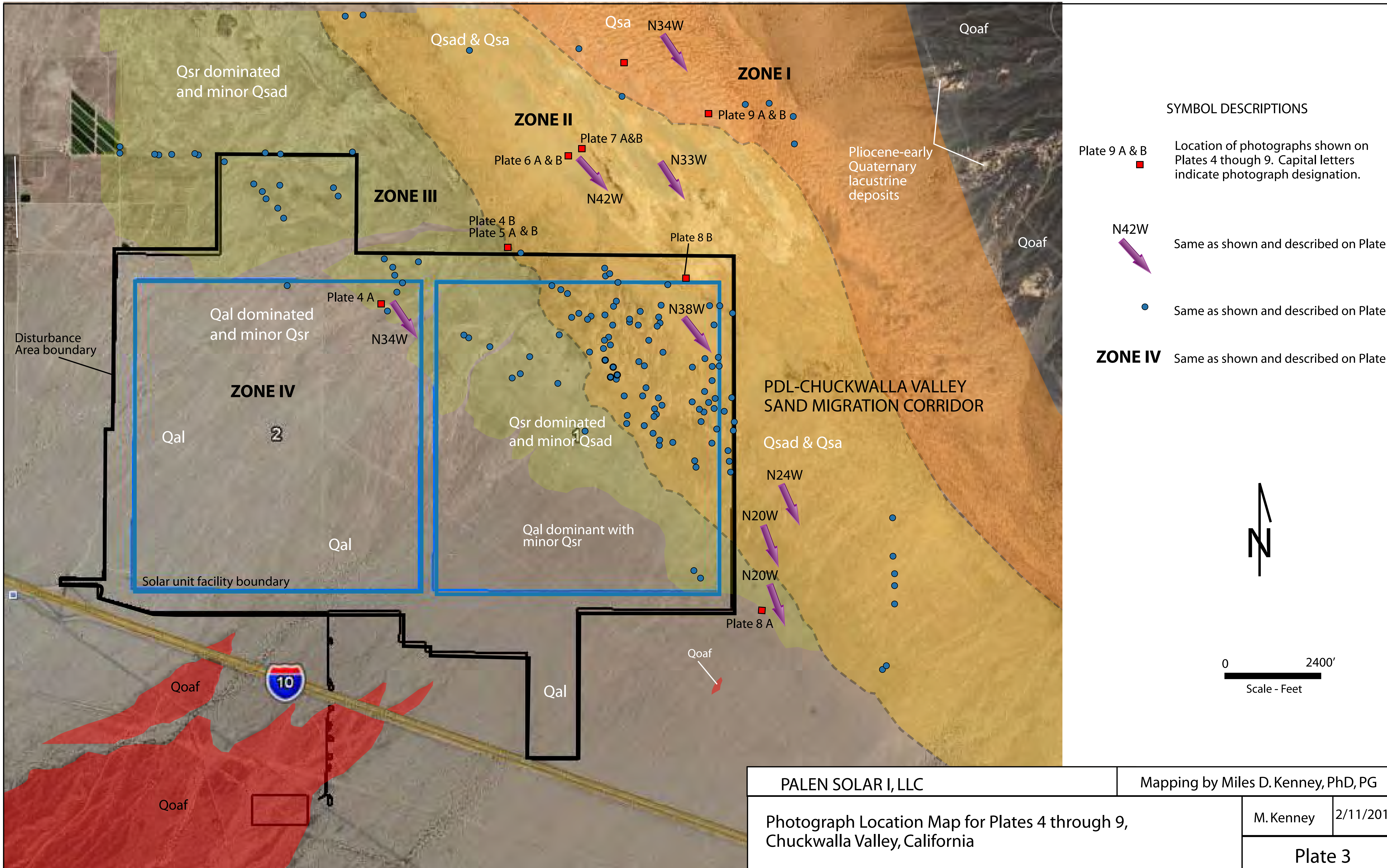
25P Ql-S0 Holocene Lake, 425' msl — Approximate location of selected site location evaluated during this study. Sites chosen to provide preliminary geomorphic and geologic information regarding the timing and location of ancient playa lake shorelines for Palen Dry Lake. Labels indicate stop number (25P), type of unit (i.e. Ql), estimated age of deposit by the evaluated soil profile (i.e. -S4), and elevation from Google Earth relative to mean sea level (i.e. 425' msl).

ZONE IV — Zones I through IV represent aeolian sand migration and depositional regions exhibiting variations in relative aeolian sand migration magnitudes within the PDL-Chuckwalla Valley sand migration corridor. The majority of the aeolian sand PDL-Chuckwalla Valley corridor migrates within Zone I which may be as high as 90% of total migrating sand in the system. Zones II, III and IV exhibit a gradual decrease in the relative magnitude of migrating sand. See text for more details.

N

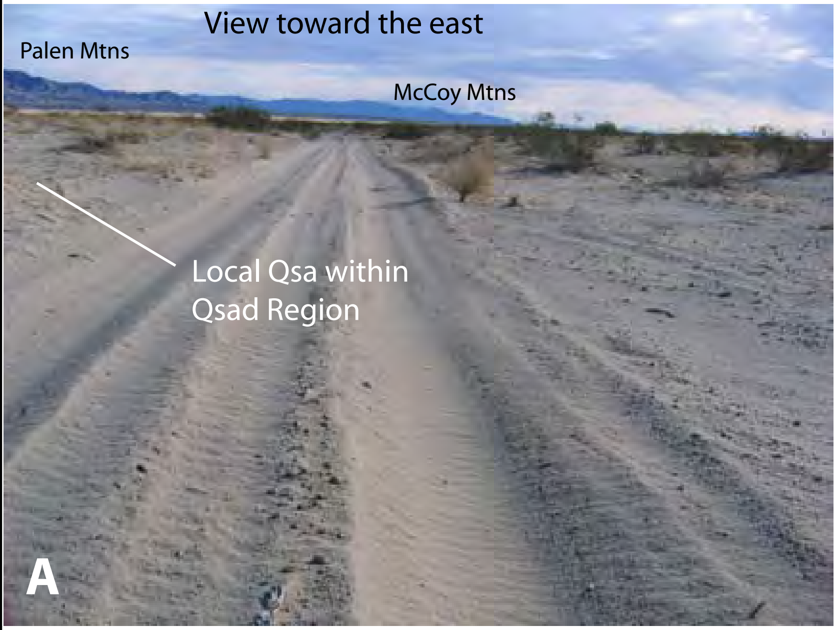
0 2400'
Scale - Feet

PALEN SOLAR I, LLC	Mapping by Miles D. Kenney, PhD, PG	
Premilinary Geologic Map with Emphasis on Aeolian Systems, Chuckwalla Valley, California	M. Kenney	2/11/2010
	Plate 2	



Qsr dominated and minor Qsad
Qsad & Qsa
Qsa
N34W
ZONE I
Qoaf
ZONE II
Plate 9 A & B
Plate 7 A&B
Plate 6 A & B
N33W
N42W
ZONE III
Pliocene-early Quaternary lacustrine deposits
Plate 4 B
Plate 5 A & B
Plate 8 B
Qoaf
Plate 4 A
Qal dominated and minor Qsr
N34W
N38W
Disturbance Area boundary
ZONE IV
PDL-CHUCKWALLA VALLEY SAND MIGRATION CORRIDOR
Qal
2
Qsr dominated and minor Qsad
1
Qsad & Qsa
N24W
N20W
Qal dominant with minor Qsr
Qal
Solar unit facility boundary
N20W
Plate 8 A
Qoaf
Qoaf
10
Qal
Qoaf
SYMBOL DESCRIPTIONS
Plate 9 A & B
Location of photographs shown on Plates 4 though 9. Capital letters indicate photograph designation.
N42W
Same as shown and described on Plate 2
Same as shown and described on Plate 2
ZONE IV
Same as shown and described on Plate 2
N
0
2400'
Scale - Feet
PALEN SOLAR I, LLC
Mapping by Miles D. Kenney, PhD, PG
Photograph Location Map for Plates 4 through 9, Chuckwalla Valley, California
M. Kenney
2/11/2010
Plate 3

BOUNDARY BETWEEN AEOLIAN MIGRATION AND DEPOSITIONAL ZONES III AND IV

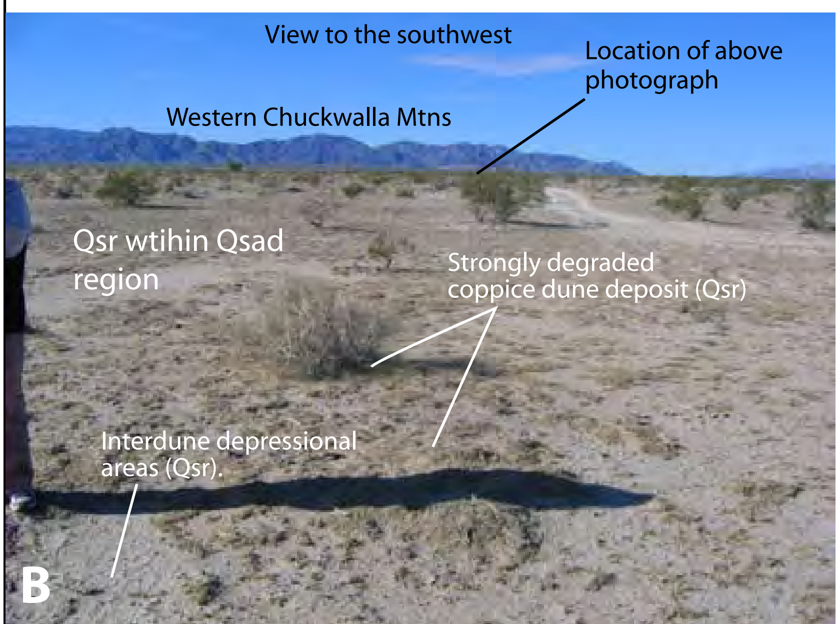


33 42.229
115 14.599 490' evlavation msl.

This photo shows active aeolian sand migration across the road. This is the first evidence of active sand migration within the site along this dirt road heading north from Highway 10.

This area represents a small outcrop of unit Qsa within a region dominated by relict aeolian deposits and alluvium (Qsr + Qal - Zone IV). Thus, this site photograph location marks the boundary between Zones III and IV.

BOUNDARY BETWEEN AEOLIAN MIGRATION AND DEPOSITIONAL ZONES II AND III



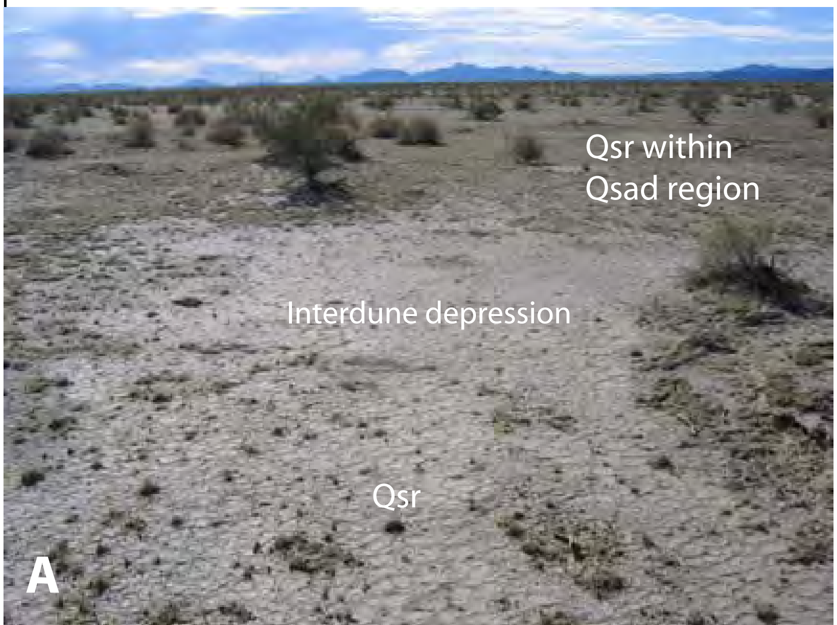
33 42.482
115 12.338 453' elevation msl.

This photograph is taken along the northeastern limits of Zone III showing an typical area of Zone III dominated by relict dune deposits (unit Qsr).

A 1-foot deep test pit at this site exhibited interbedded ripple sand deposits (sand sheets) interbedded with interdune depressional silt deposits associated with local ponding.

PALEN SOLAR I, LLC		Miles D. Kenney PhD, PG	
PHOTOGRAPHS	MK		2/11/2010
	JN 708-09	PLATE 4	

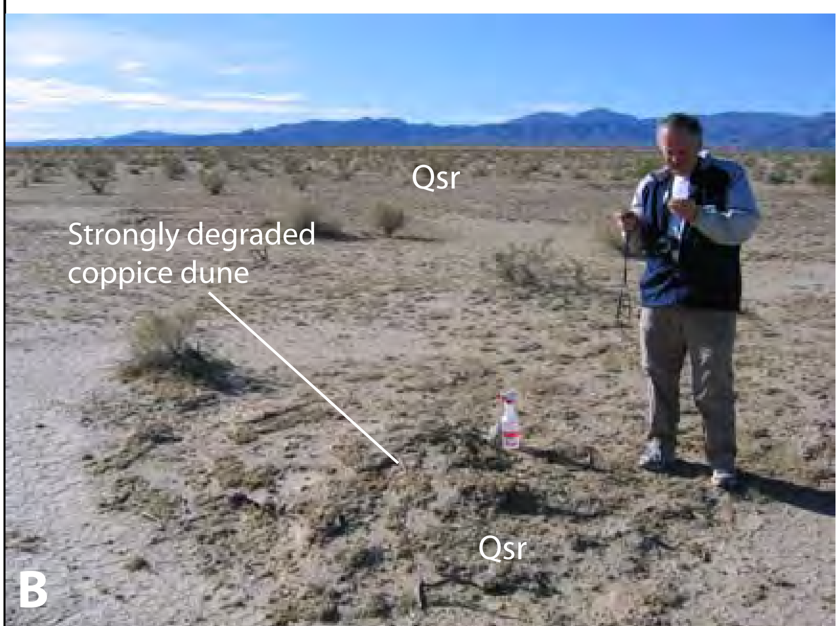
BOUNDARY BETWEEN AEOLIAN MIGRATION AND DEPOSITIONAL ZONES II AND III



33 42.482
115 12.338 453' elevation msl

View toward the southeast and aeolian migration and depositional Zone III.

Photograph exhibits typical Qsr region containing interdune depressions, degraded coppice dunes and strong vegetation.



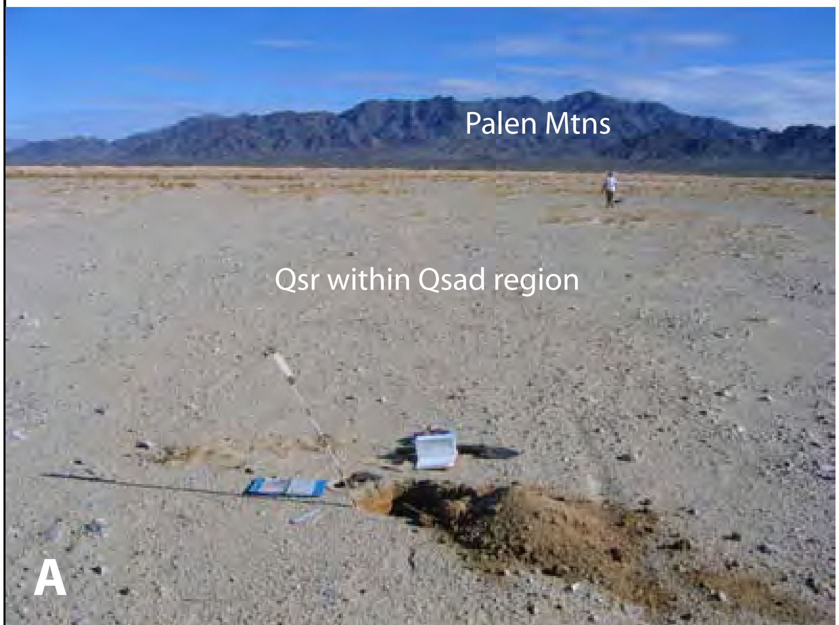
33 42.482
115 12.338 453' elevation msl.

View toward the south and aeolian migration and depositional Zone III.

Photograph showing strongly degraded and vegetated coppice dune.

PALEN SOLAR I, LLC		Miles D. Kenney PhD, PG		
PHOTOGRAPHS	MK		2/11/2010	
	JN 708-09	PLATE 5		

AEOLIAN MIGRATION AND DEPOSITIONAL ZONE II

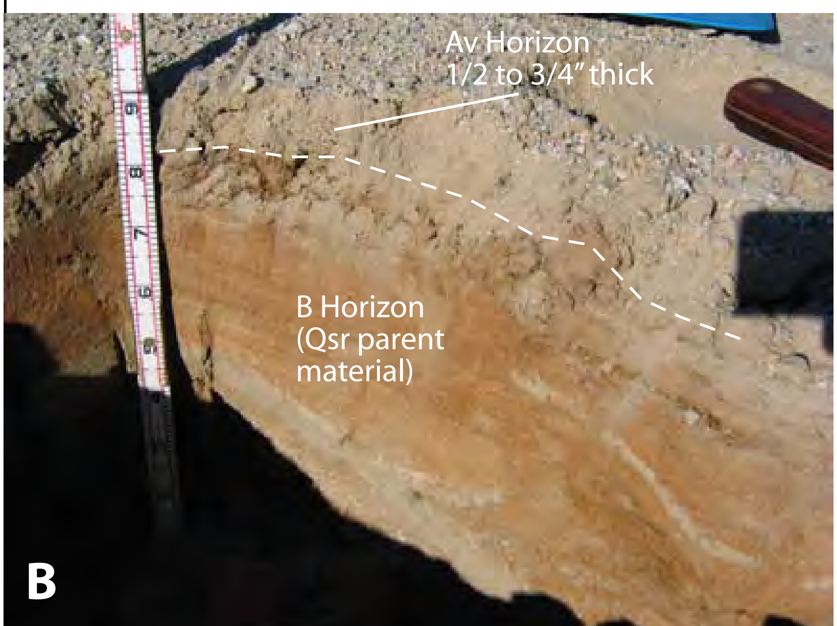


33 42.891
115 12.031 Elevation 426' msl.

View toward the north and the Palen Mountains.

Photogrph exhibits the test pit shown in below photograph and the wind gravel wind lag deposit on the surface. Note the lack of active dunes within this portion of Zone II. Aeolian sand migrates over this surface toward the southeast.

3 to 4-inch long active coppice dune tails were identifed at this location with wind coming from N30W.



33 42.891
115 12.031 Elevation 426' msl.

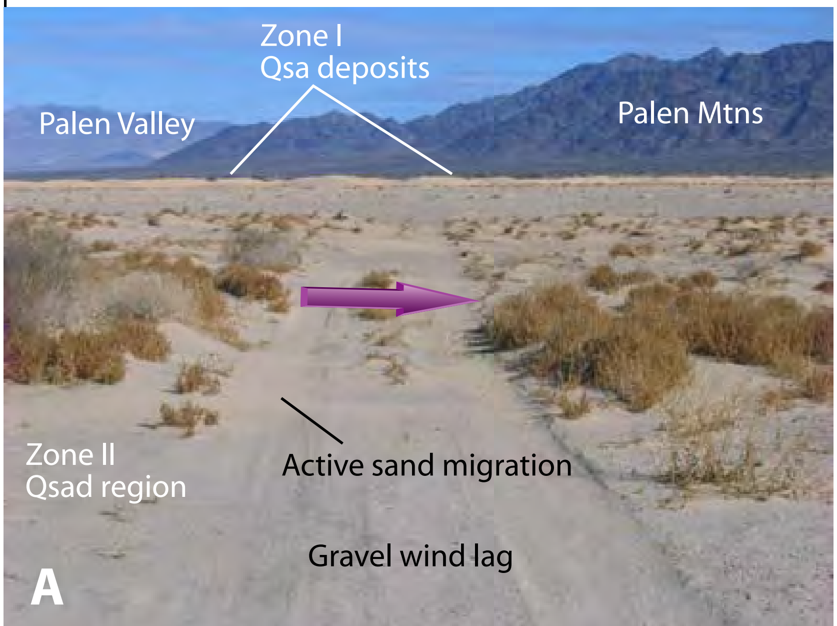
Test pit shown in above photograph.

Test pit exibits interbedded sand sheet deposits (Qsr), thin likely interdune silt deposits, and alluvium (Qal).

Surface soil profile is likely in the age range of 5 to 8 kya (S3a). The surface soil, gravel wind lag, and Qsr near surface deposits indicate that a playa lake has not existed at elevation 426' since the early to mid Holocene.

PALEN SOLAR I, LLC	Miles D. Kenney PhD, PG		
PHOTOGRAPHS	MK		2/11/2010
	JN 708-09	PLATE 6	

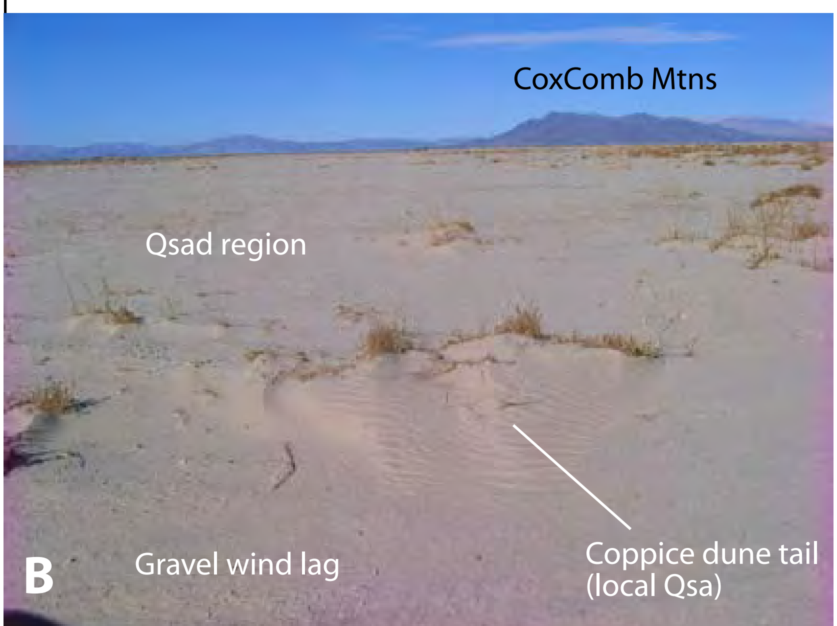
AEOLIAN MIGRATION AND DEPOSITIONAL ZONE III



33 42.916
115 11.966 424' Elevation msl.

Photograph view toward the northeast and the Palen Mountains.

Area within Zone III demonstrating active aeolian sand migration across the road from areas of stabilized coppice dunes. These very small wind blown deposits are maintained by aeolian sand but are not growing substantially. Area is mapped as Qsad which represents regions of migrating sand but exhibits limited areas of active dunes (Qsa).



33 42.916
115 11.966 424' Elevation msl.

Same location as Photograph A above.

Photograph view toward the northwest (N42W) in the direction that the wind comes from.

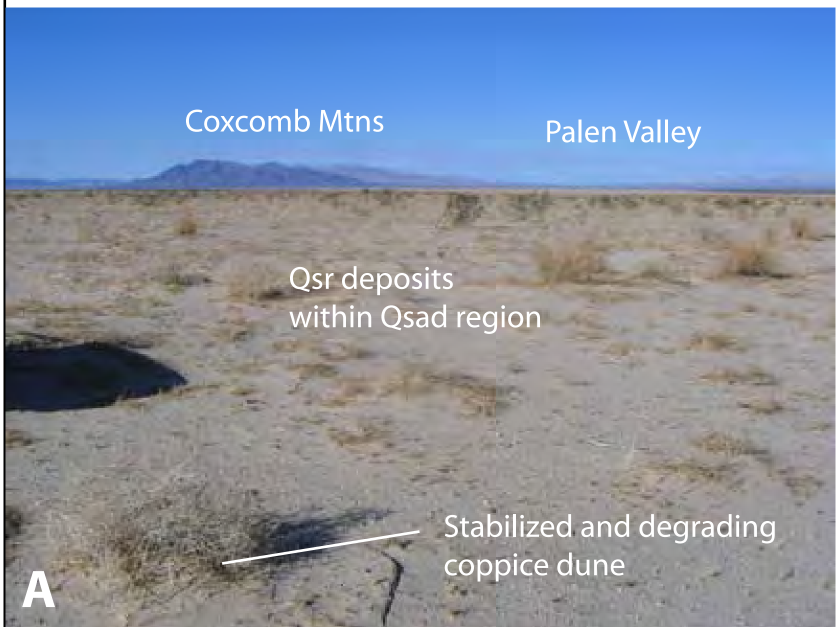
A relatively small active coppice dune tail is observed with active ripples. Coppice dune tail provides evidence of recent aeolian sand migration and direction. Supports Qsad designation.

PALEN SOLAR I, LLC	Miles D. Kenney PhD, PG

PHOTOGRAPHS

MK		2/11/2010
JN 708-09	PLATE 7	

NEAR BOUNDARY BETWEEN AEOLIAN MIGRATION AND DEPOSITIONAL ZONES III AND IV



33 40.914
115 11.057 487' Elevation msl.

Phtograph view toward the northwest and the southern Coxcomb Mountains.

The photographs shows the typical surficial deposits and vegetation within Zone IV. A test pit at this location to a depth of 1.5-feet exhibited interbedded relict sand sheet (Qsr) and alluvim (Qal) deposits.

AEOLIAN MIGRATION AND DEPOSITIONAL ZONE II

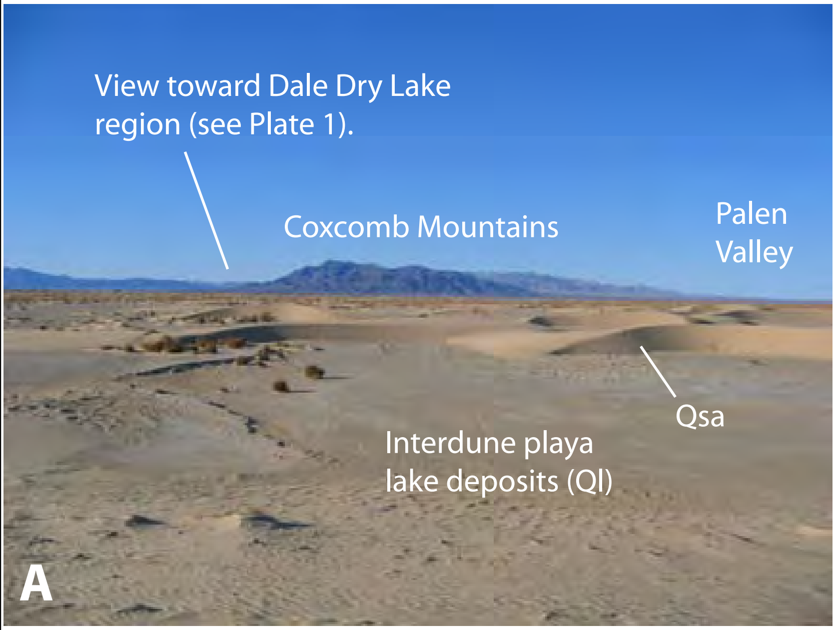
33 42.349
115 11.432 428' Elevation msl.

View toward the north to northwest and the Palen Valley.

Photographs exhibits and area within Zone II mapped as Qsad where wind abrassion is occuring within existing surficial sediments consisting of older wind blown sand (Qsr), interdune depression silts, and older alluvial fan (Qoaf).

PALEN SOLAR I, LLC	Miles D. Kenney PhD, PG		
PHOTOGRAPHS	MK		2/11/2010
	JN 708-09	PLATE 8	

AEOLIAN MIGRATION AND DEPOSITIONAL ZONE I

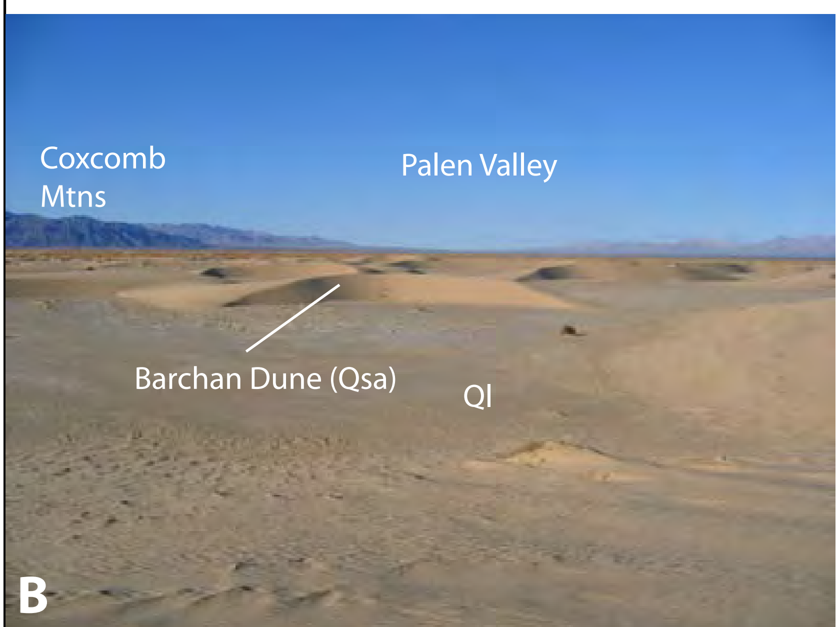


33 43.068
115 11.315 424' Elevation msl.

View toward the northwest and the Coxcomb Mountains.

Photograph within aeolian migration and depositonal Zone I containing abundant Qsa deposits.

This photogrph exhibits interdune areas exposing late Holocene playa lake deposits and transverse dunes (barchans).



Same location as above but view toward Palen Valley (north northwest).

Photographs exhibits well formed barchan dunes.

PALEN SOLAR I, LLC	Miles D. Kenney PhD, PG		
PHOTOGRAPHS	MK		2/11/2010
	JN 708-09	PLATE 9	

STATE OF CALIFORNIA
ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION

In the Matter of:
APPLICATION FOR CERTIFICATION
for the *PALEN SOLAR POWER PROJECT*

Docket No. 09-AFC-7
PROOF OF SERVICE
(Revised 12/28/2009)

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DECLARATION OF SERVICE

I, Carl Lindner, declare that on, February 12, 2010, I served and filed copies of the attached Palen Solar Power Project Data Response materials:

Supplemental Responses to CEC Data Requests
Technical Areas:
Biological Resources – DR-BIO-60 through DR-BIO-62
& Preliminary Geomorphic Aeolian and Ancient Lake Shoreline Report

The original document, filed with the Docket Unit, is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at:

[http://www.energy.ca.gov/sitingcases/solar_millennium_palen]

The document has been sent to the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission's Docket Unit, in the following manner:

(C*heck all that Apply*)
For service to all other parties:

__X__ sent electronically to all email addresses on the Proof of Service list;

_____ by personal delivery or by overnight delivery service or depositing in the United States mail at Camarillo, California with postage or fees thereon fully prepaid and addressed as provided on the Proof of Service list above to those addresses **NOT** marked "email preferred."

AND

For filing with the Energy Commission:

__X_ sending an original paper copy and one electronic copy, mailed to the address below (preferred method);

OR

_____ depositing in the mail an original and 12 paper copies, along with 13 CDs, as follows:

CALIFORNIA ENERGY COMMISSION
Attn: Docket No. 09-AFC-7
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512

docket@energy.state.ca.us

I declare under penalty of perjury that the foregoing is true and correct.

Carl E. Lindner